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NITROGEN

THE MAGAZINE OF WORLD NITROGEN

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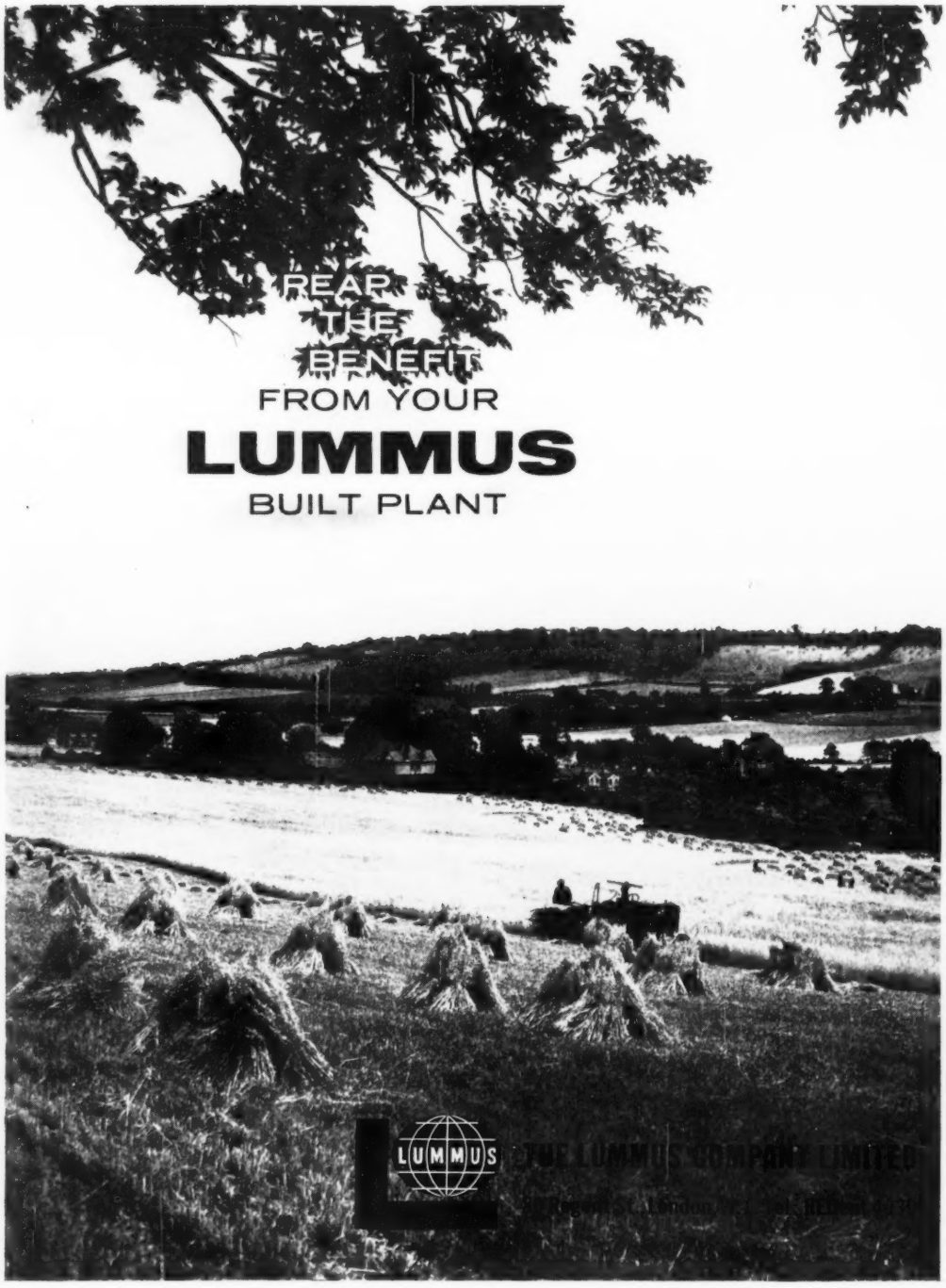
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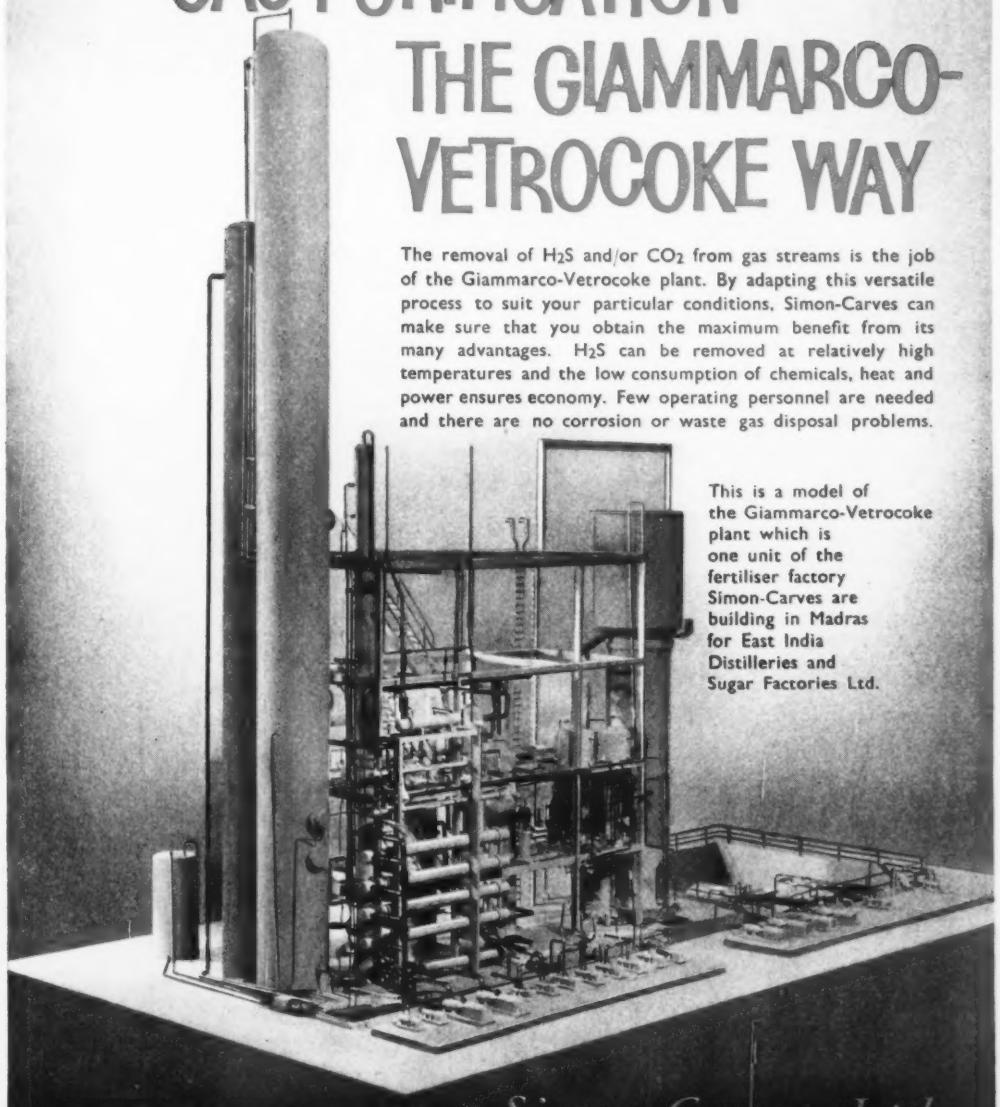

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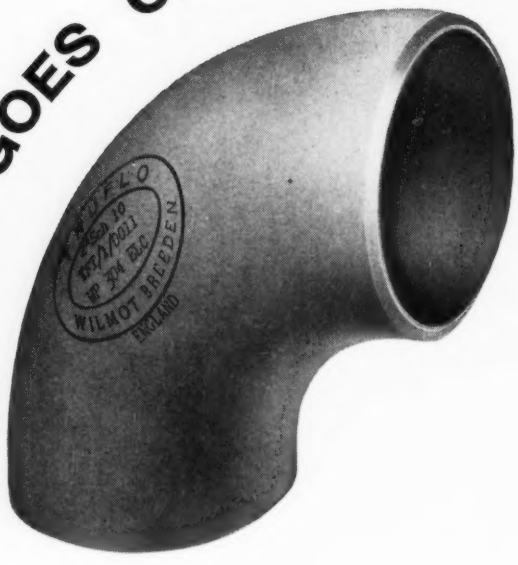

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Caprolactam Processes and Ammonia Requirements

Ammonium sulphate yielded as by-product

In all caprolactam processes at present employed ammonia is used to neutralize sulphuric acid and hence considerable quantities of ammonium sulphate are produced varying from about 2 to 5 tons ammonium sulphate per ton of caprolactam produced. By 1962 it is estimated that by-product ammonium sulphate will amount to 1.4 million tons.

RAPID expansion of the market for nylon-6 is being accompanied by the establishment of new production facilities for its raw material—caprolactam. These developments are evident on a large scale in the countries with major chemical industries, notably U.S.A., U.K., Germany, Italy, Netherlands and Japan, and also on a smaller scale elsewhere.

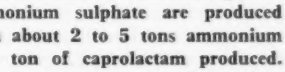
The significance to the nitrogen industry is twofold in that caprolactam is a large consumer of technical N and the processes used yield ammonium sulphate as a by-product. The commercial value of ammonium sulphate, which is obtained in varying amounts from different processes, is one of the criteria in evaluating them. Moreover, large quantities of by-product ammonium sulphate cannot fail to make an impact on the pattern of nitrogenous fertilizer supplies, but to date only in Japan is there a rationalised plan to integrate caprolactam-nylon-6 production with the established output of ammonium sulphate.

Nylon-6

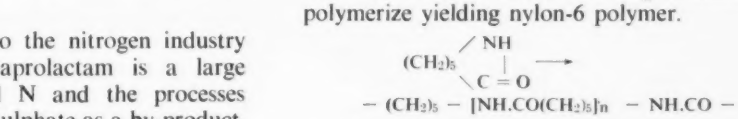
Nylon-6 was introduced commercially in the U.S.A. in 1954 and by 1958 output is estimated to have reached 38 million lb. In 1960 output was close to the available plant capacity of 42 million lb. In Europe, nylon-6 output greatly exceeds the U.S. figure, and production facilities are known to make up a major part of the 300 million lb. a year polyamide fibre capacity on stream during 1960. In Japan nylon-6 has been produced for nearly 10 years by the two leading textile producers—Toyo Rayon Company and Nippon Rayon Company.

Chemistry

Caprolactam has the following structural formula:—



When pure it is a crystalline solid with a melting point of 70°C. Prolonged heating at 260° to 270°C causes the caprolactam to polymerize yielding nylon-6 polymer.



In the pure state caprolactam contains 12.4% N by weight equivalent theoretically to 153 kg. ammonia per 1,000 kg. of caprolactam. The total ammonia requirements in the production of caprolactam are, however, much greater, depending on the process employed—up to 1,600 kg. ammonia per 1,000 kg. caprolactam—but processing yields up to 5,000 kg. of ammonium sulphate as by-product (1,276 kg. NH_3).

Commercial Synthesis of Caprolactam

There are several routes in use commercially for the synthesis of caprolactam:—

(a) Schlach Process (phenol, cyclohexane)
(b) Zimmer Process (phenol, cyclohexane or aniline)
(c) Inventa AG./Emser Werke AG. Process (cyclohexane)
(d) Snia Viscosa Process (toluene)
(e) Irradiation processes (cyclohexane)

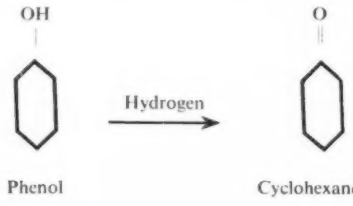
At present the greater part of caprolactam production is based on cyclohexanone, which is obtained from phenol and from cyclohexane. In some instances benzene is used as starting material.

Conversion of cyclohexanone to caprolactam involves two chemical steps: production of cyclohexanone oxime and the subsequent Beckman rearrangement of the oxime.

Common to all synthesis methods for caprolactam is the cyclohexanone oxime to caprolactam stage. Several processes are in use commercially to produce cyclohexanone oxime, older processing using phenol as raw material. More recently, other synthetic routes have been developed, using cyclohexane, toluene and aniline.

German Route from Phenol

Developed in Germany during the Second World War by Dr. Paul Schlach, the phenol route has been employed in Western and Eastern Germany and since 1954 in the U.S.A.

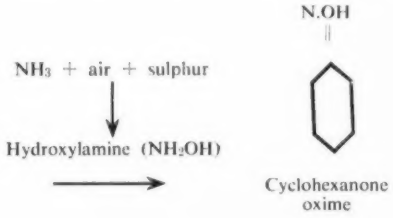


Companies using the phenol route are: *West Germany*, Badische Anilin-und Soda-Fabrik AG., Ludwigshafen, Chemische Werke Huls AG., Marl, Recklinghausen, and Farbenfabriken Bayer AG., Leverkusen; *Netherlands*, Staatsmijnen in Limburg, Geleen; *U.S.A.*, Allied Chemical Corporation; *Eastern Germany*, Leuna Werke AG.

For each ton of caprolactam produced five tons of ammonium sulphate is obtained as by-product: 2.4 tons is formed in the preparation of hydroxylamine, 0.6 tons during oxime formation and two tons in the Beckman rearrangement to the lactam.

In the commercial process, which is a batch operation, a solution of hydroxylamine sulphate, cooled to 20°C, is mixed with cyclohexanone in 5% excess. Ammonia is passed in with vigorous stirring until the mixture becomes neutral. The product is transferred to a separator where the oxime settles out as an oily liquid containing 4 to 5% water. The crude oxime is used as feedstock for the Beckman rearrangement whereby it is converted to caprolactam. Sulphuric acid is used as catalyst, although a recent development by Badische-Anilin und Soda-Fabrik indicates that use of hydrochloric acid may have certain advantages. Molten cyclohexanone oxime (20lb.) sulphuric acid (32lb. of 97.8% H_2SO_4) are introduced at separate points in the reactor vessel; operating temperature is held below 140°C and the product is withdrawn continuously from the system. Caprolactam-containing solution is rapidly cooled to below 50°C to avoid hydrolysis, and then cooled further and neutralized with ammonia.

After phase separation, caprolactam is recovered by vacuum distillation or by solvent extraction using benzene. Yield, based on oxime, is stated to be 90 to 93% of theory.



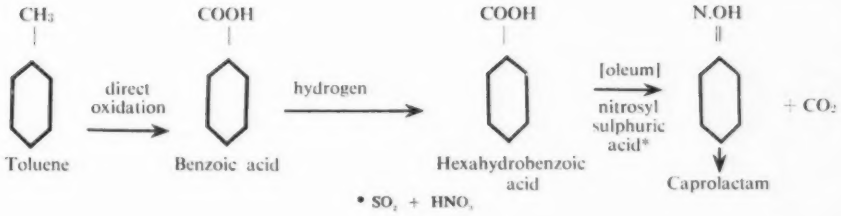
Snia Viscosa Process

Based on the use of toluene as raw material the Snia Viscosa process involves the reaction of hexahydrobenzoic acid with nitrosylsulphuric acid. Intermediate reactions are required. These are:—

(a) Production of nitrosylsulphuric acid by reacting sulphur dioxide with fuming nitric acid.

(b) Production of benzoic acid from toluene by oxidation with air, SO_2 or sulphur, using bromine-promoted manganese salts or ketone-promoted cobalt salts as catalysts. Liquid-phase air oxidation can also be employed. The benzoic acid is hydrogenated to hexahydrobenzoic acid in alcoholic solution using chlorine-free palladium or platinum as catalyst.

Conversion of hexahydrobenzoic acid to caprolactam is carried out with nitrosyl-sulphuric acid in excess in the presence of oleum. The total quantity of sulphuric acid including that required in nitrosylation is 2.5



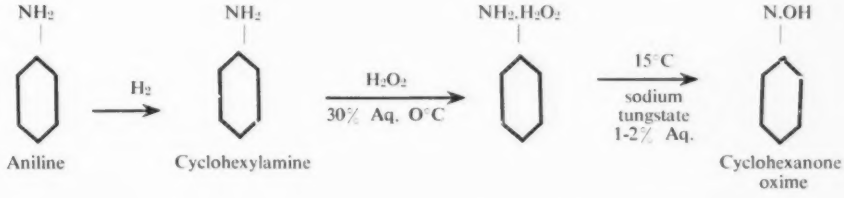
mols per mole organic feed material. The temperature is gradually raised from 55° to 65°C until evolution of carbon dioxide ceases.

Ultimate yield of caprolactam is about 80 to 90% and about 4.5 tons of ammonium sulphate is obtained as by-product for each ton of caprolactam produced.

Cyclohexylamine Route

Cyclohexylamine is produced by hydrogenation of aniline, using nickel, cobalt or ruthenium oxide as catalyst, or alternatively the amine is obtained from cyclohexanol by reaction with ammonia and hydrogen over a Raney nickel-type catalyst.

Conversion of cyclohexylamine to cyclohexanone oxime is effected by reaction with 30% aqueous hydrogen peroxide solution. In one commercial scale process a two-stage conversion is employed. At first an addition compound of the amine is formed at 0°C, followed by conversion to the oxime at 15°C. In the second stage a 1 to 2% aqueous solution of sodium or ammonium tungstate is added as a catalyst. Yield of cyclohexanone oxime of 99.9% purity is reported at 94 to 95% of theory. The product is converted to caprolactam by the Beckman rearrangement.

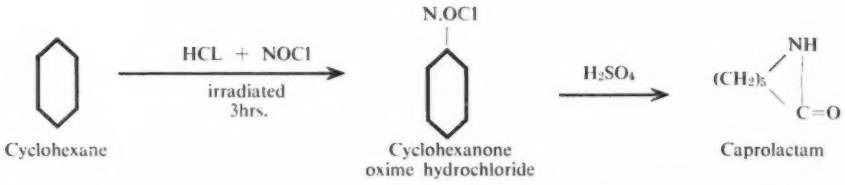


Zimmer Process

Hans J. Zimmer, of Berlin, which is 50% owned by High Polymers and Petrocarbon Limited, of London, has developed a process for caprolactam manufacture in which the raw material is benzene. Cyclohexane is produced from this and then cyclohexanone. A high oxidation yield of 85% compared with 60% by other processes and adipic acid formation are claimed.

Irradiation Processes

Toyo Rayon Company Limited's research department has developed a photochemical process for caprolactam manufacture. This will be used when the company increases its production capacity which at present is based on the phenol route. The new process described in Japanese Patent N. 216,535 is claimed to be superior economically to the Snia Viscosa process which the company has also investigated. Raw material is cyclohexane into which nitrosyl chloride is diffused and the mixture is subjected to light energy in the 3,650 to 6,000 Angstrom range using preferably a high pressure mercury lamp, at a temperature of 5° to 30°C. An immediate reaction takes place resulting in a colour change to yellow or green while a yellow oily layer of cyclohexanone oxime forms as a bottom layer. Hydrochloric acid catalyses the reaction, optimally at 20 to 30°C. Unconverted cyclohexane is recycled, the oxime and its salt are separated and taken up in water. The solution formed is neutralized with caustic soda or barium carbonate until the pH is 6.5.



The oxime is then converted to caprolactam using conventional techniques and it is believed that this route yields 2.5 tons ammonium sulphate per ton of caprolactam produced.

BASF has also investigated irradiation of cyclohexane and it is suggested that Dow Badische in the U.S. may be using a similar route.

After heating the cyclohexane with hydrochloric acid and nitrosyl chloride and irradiating for three hours the oxime chloride is produced (yield 61% on NOCl). The oxime is converted to caprolactam in the usual way. In this process 2.5 tons of ammonium sulphate are obtained per ton of caprolactam produced.

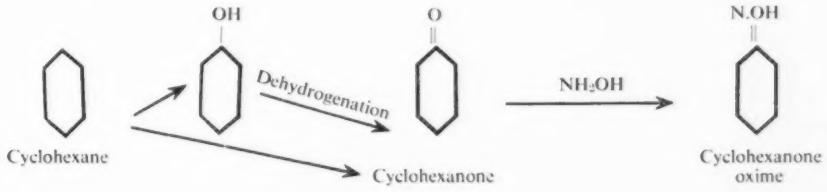
Inventa Processes

One process developed by Inventa AG., of Switzerland, is known to start from toluene and to produce ammonium sulphate as by-product. The other Inventa process has been developed in conjunction with Emser Werke AG., also of Switzerland, and is the choice of Imperial Chemical Industries Limited. No details are yet known about this process, but it is believed that it may use either cyclohexane or toluene as starting material.

The two nylon-6 plants and the caprolactam facility at Nagoya of Toyo Rayon Limited. The first plant is in the foreground and the second plant is at the top left

Du Pont Process

The route developed by E.I. Du Pont de Nemours and Company is based on cyclohexane and is being used at the company's plant now on stream at Beaumont, Texas. Du Pont has stated that using its process it can make and sell caprolactam at a lower price than material produced by Allied Chemical Corporation from its present phenol-based process. Conversion of cyclohexane to cyclohexanone oxime probably occurs as follows:—

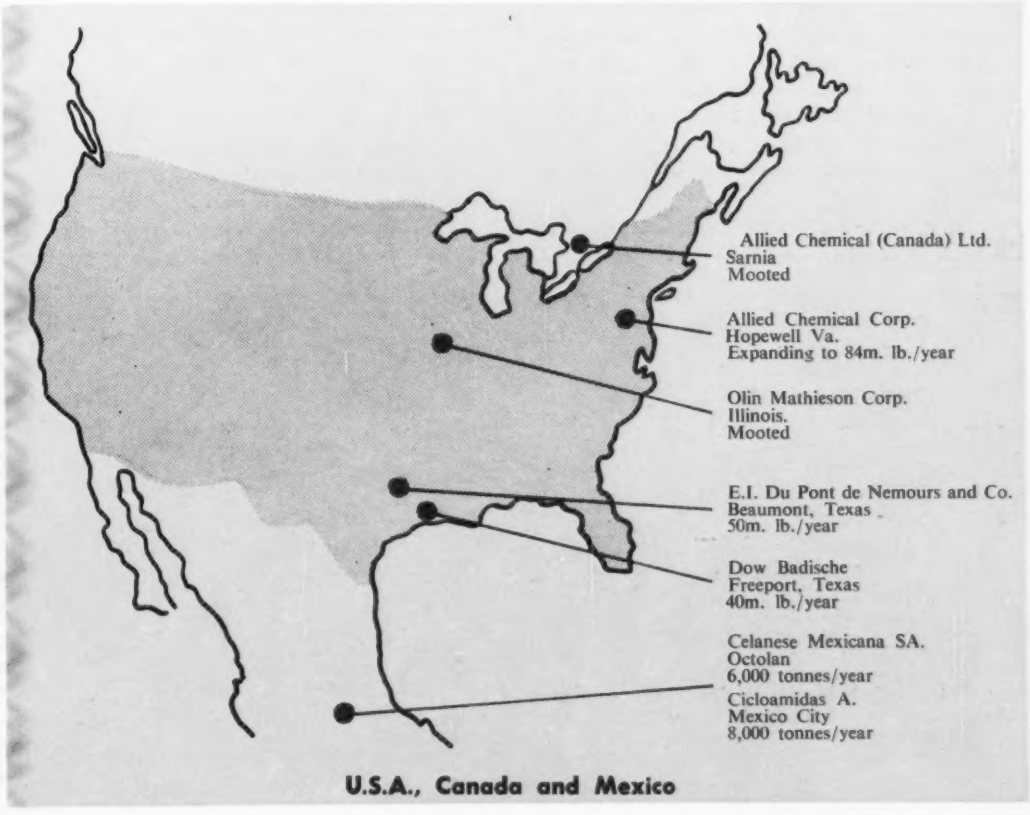


Du Pont has yet another process, however, whereby cyclohexane is converted to nitrocyclohexane which is pyrolyzed to caprolactam. No ammonium sulphate is produced.

Other Processes

Another U.S. concern, Commercial Solvents Incorporated, reports that it has a cyclohexane-based process now in an advanced pilot plant stage at Terre Haute, Ind.

A process which has not been developed



U.S.A., Canada and Mexico

commercially as far as it is known is based on the Novotny patents. Cyclohexane is the starting material. It is treated with nitroparaffin and concentrated sulphuric acid. Yield of by-product ammonium sulphate is 2.0 tons for each ton of caprolactam.

PRODUCERS

U.S.A.

Allied Chemical Corporation, the world's largest producer of caprolactam, increased production in July 1960 at its Hopewell, Va., plant from 60 million lb. to 80 to 90 million lb. At the same time construction of a new unit to increase output potential by 75% was started and this, now about to come on stream, will raise the company's installed capacity to 140 million lb. a year.

The original unit and its extension use the phenol-based process and although the new Hopewell plant was expected to use the Snia Viscosa route, based on toluene, it is now believed that Allied will not use the Italian process after all. By-product ammonium sulphate capacity from Allied's caprolactam output is expected to be over 250,000 s. tons and if all three units are phenol-based, the potential ammonium sulphate arising would be about 350,000 s. tons.

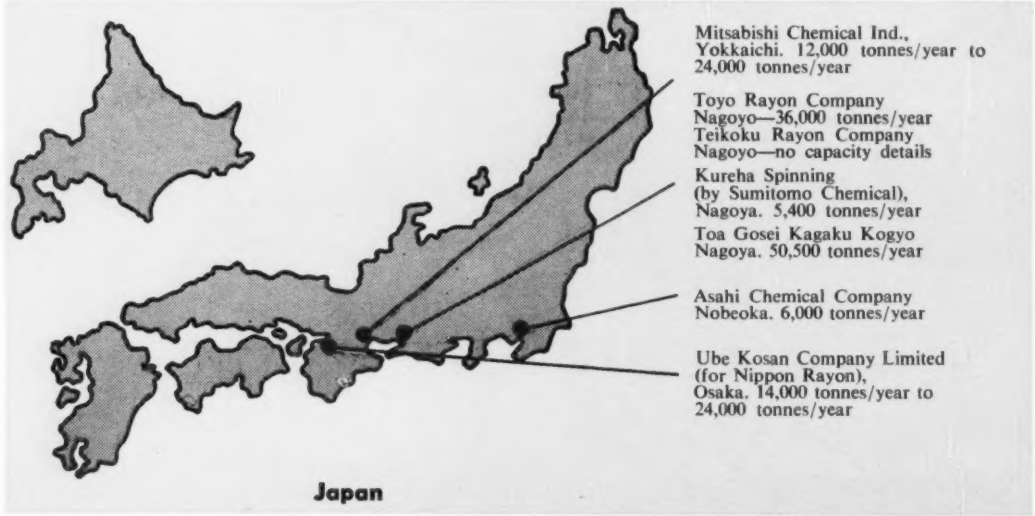
Dow Badische, a joint subsidiary of Dow Chemical Company and BASF Overzee N.V., is erecting a caprolactam plant at Freeport, Texas, which, with an estimated capacity of 40 million lb. a year will be completed in early 1962. If the new BASF irradiation process is used little or no ammonium sulphate will arise.

E.I. Du Pont de Nemours and Company is operating a 50 million lb. a year plant at Beaumont, Texas, which came on stream recently.

Japan

Ube Kosan Company produces caprolactam for use by Nippon Rayon Company in nylon-6 manufacture at Osaka. Nippon Rayon use 1,200 tonnes of caprolactam per month in the production of filament yarn including tyre cord, staple fibre and caprolactam plastics. In 1963, the company's consumption of caprolactam will rise to 2,000 tonnes a month. At present Ube Kosan obtains 50% of its cyclohexanone by the phenol route and 50% by the benzole-cyclohexane route. After 1962, production at its present level and, following the expansion, to 2,000 tonnes per month will be based on cyclohexane derived from a petroleum source.

Ammonium sulphate arising as by-product of caprolactam manufacture in the ratio of 4 to 1 totals 57,500 tonnes a year. Ube Kosan is examining the Inventa process as this offers the possibility of lower ammonia and sulphuric


Mitsabishi Chemical Ind., Yokkaichi. 12,000 tonnes/year to 24,000 tonnes/year
Toyo Rayon Company Nagoyo—36,000 tonnes/year
Teikoku Rayon Company Nagoyo—no capacity details
Kureha Spinning (by Sumitomo Chemical), Nagoya. 5,400 tonnes/year
Toa Gosei Kagaku Kogyo Nagoya. 50,500 tonnes/year
Asahi Chemical Company Nobeoka. 6,000 tonnes/year
Ube Kosan Company Limited (for Nippon Rayon), Osaka. 14,000 tonnes/year to 24,000 tonnes/year
Japan

acid consumption and a reduced outfall of by-product ammonium sulphate.

Toyo Rayon Company has produced caprolactam and nylon-6 since about 1950. At present caprolactam capacity is about 100 tonnes a day and 500 tons a day of ammonium sulphate is produced as by-product which is sent to Toa Gosei Kagaku Kogyo — by whom it is marketed as fertilizer. Toa Gosei itself produces annually some 50,000 tonnes caprolactam and 200,000 tonnes by-product ammonium sulphate.

Asahi Chemical Company has obtained approval from MITI for construction of a 16-tonne a day caprolactam plant. The company has a contract with Zimmer company of West Germany for a licence, know-how and engineering for caprolactam and nylon-6 manufacture. In the first stage, 6 tonnes of nylon a day will be produced, some of which will be exported.

toluene route. Production is due to start at the end of 1962.

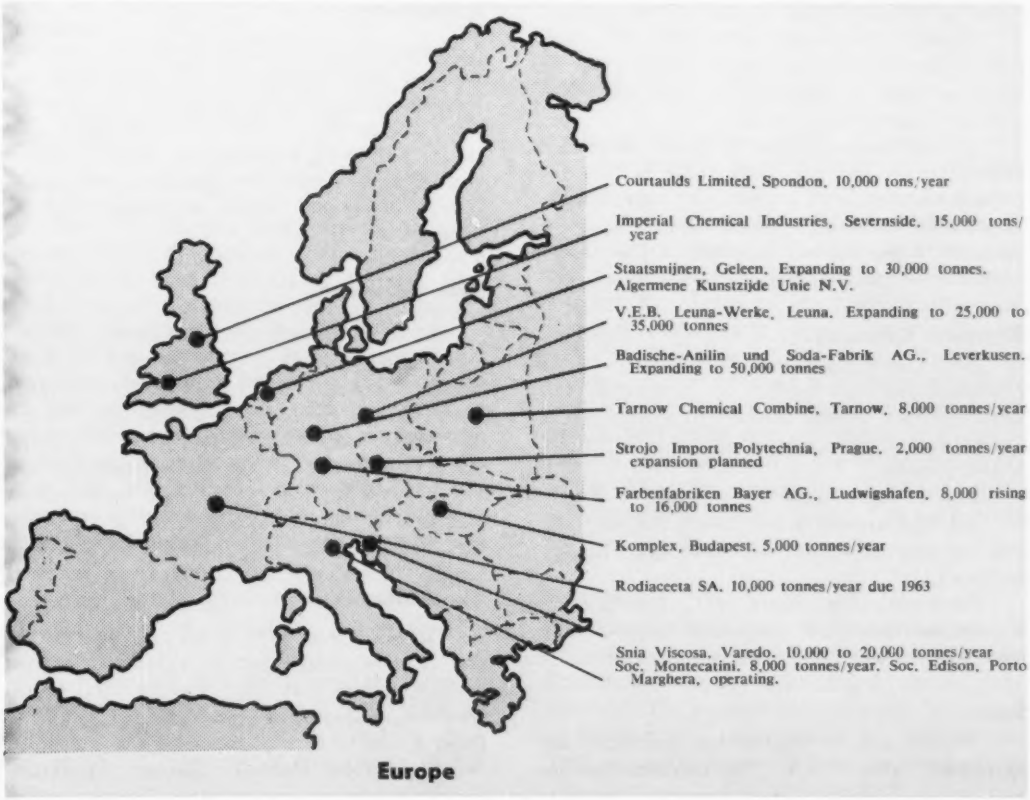
Kureha Chemical Company will also manufacture caprolactam using the Zimmer process. A 15-tonne-a-day plant is planned.

Teikoku Rayon Company has recently been licensed by Snia Viscosa to make nylon-6 using the Snia Viscosa process.

United Kingdom

Imperial Chemical Industries Limited announced in June that it had concluded an agreement whereby it had acquired rights to the Emser Werke/Inventa new processes for the manufacture of caprolactam and nylon-6.

According to Dr. G. Collin, I.C.I.'s nylon works manager at Wilton, trial lots of cyclohexane have been obtained by I.C.I. from Texas via Dordrecht, Netherlands. Recently I.C.I. was granted a patent for the manufacture of nitrosyl chloride (British Patent 844,789)


Courtaulds Limited, Spondon, 10,000 tons/year
Imperial Chemical Industries, Severnside, 15,000 tons/year
Staatsmijnen, Geleen, Expanding to 30,000 tonnes. Algemene Kunstzijde Unie N.V.
V.E.B. Leuna-Werke, Leuna, Expanding to 25,000 to 35,000 tonnes
Badische-Anilin und Soda-Fabrik AG., Leverkusen. Expanding to 50,000 tonnes
Tarnow Chemical Combine, Tarnow, 8,000 tonnes/year
Strojo Import Polytechnia, Prague, 2,000 tonnes/year expansion planned
Farbenfabriken Bayer AG., Ludwigshafen, 8,000 rising to 16,000 tonnes
Komplex, Budapest, 5,000 tonnes/year
Rodiaceeta SA, 10,000 tonnes/year due 1963
Snia Viscosa, Varedo, 10,000 to 20,000 tonnes/year
Soc. Montecatini, 8,000 tonnes/year. Soc. Edison, Porto Marghera, operating.

Europe

whereby gaseous nitrogen dioxide, diluted with nitrogen or air—as in gases obtained during the catalytic oxidation of ammonia—is passed, preferably at a low temperature, 21°C at atmospheric pressure, over solid ammonium chloride particles kept in movement either alone or with the presence of water which is between 2.0 to 0.25% by weight of the ammonium chloride.

While I.C.I. has rights for the technical know-how and patents relating to the Emser Werke/Inventa new processes, for caprolactam and nylon-6 manufacture, the company may only partly apply the process, modifying it by its own techniques. From I.C.I.'s viewpoint it is thought that the process chosen should yield either a large quantity of ammonium sulphate as by-product or none at all.

Construction of a caprolactam plant, which initially will have a capacity of 15,000 tons a year, is due to begin shortly at Severnside, where a nylon-6 plant is also to be erected.

Courtaulds Limited is building a 10,000 tons a year caprolactam and a nylon-6 plant at Spondon and is expected to use the Snia Viscosa toluene-based process.

British Enka Limited, at Irvine, Northern Ireland, is to build a nylon-6 plant, but for the present no decision to manufacture caprolactam appears to have been made. The company's parent, Algemene Kunstzijde Unie N.V. (A.K.U.) of the Netherlands, may supply.

Western Germany

Badische-Anilin und Soda-Fabrik AG., Ludwigshafen, has decided to increase caprolactam output during 1961-62 to about 50,000 tonnes a year from a level of about 30,000 to 35,000 tonnes.

Part of the output will be used by BASF for making Ultramid, a polyamide, but the bulk will be sold to Perlon (nylon-6) fibre manufacturers.

Farbenfabriken Bayer AG., Leverkusen, is also increasing its output of caprolactam from 8,000 tonnes to 15,000 tonnes a year.

Spain

Perlofil S.A. of Madrid has concluded an agreement with A.K.U. for co-operation in the production of polyamides. Formed in 1957, Perlofil is one of Spain's three nylon-producing companies and produces nylon-6 yarns and fibres. The Spanish company will have A.K.U.'s technical assistance in a projected expansion of its nylon-6 facilities, which may include caprolactam.

Italy

Snia Viscosa, which has its own process, has successfully concluded trial runs on a 200 kg. a day pilot-plant at Varedo. The company is now building a 10,000 tonnes a year commercial plant and expansion to 20,000 tonnes a year is foreseen.

Soc. Montecatini produces caprolactam in conjunction with Rhodiatoce S.p.A. Installed capacity is 8,000 tonnes, but current output is about 1,500 tonnes. *Soc. Edison* operates a caprolactam plant at Porto Marghera.

Netherlands

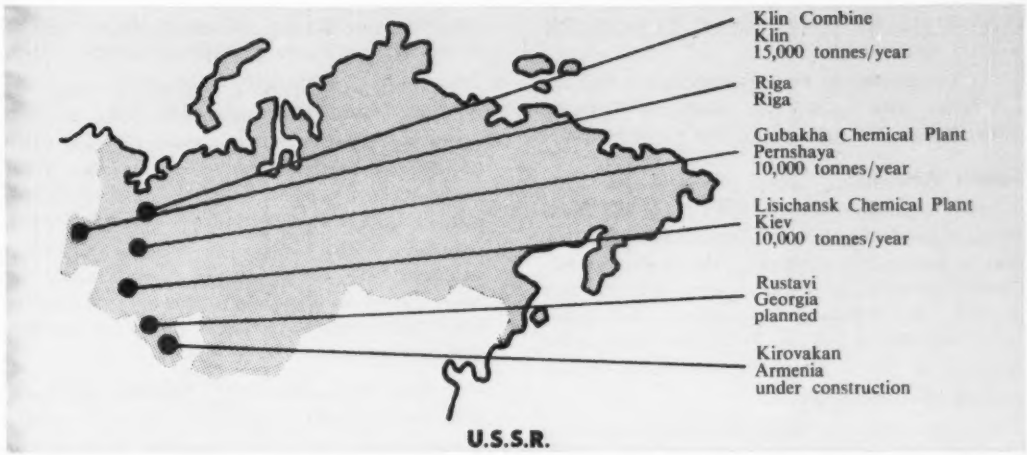
Algemene Kunstzijde Unie N.V., in conjunction with *Staatsmijnen N.V.* at Geleen, has been producing 6,000 tonnes of caprolactam since about 1957, and it is reported that capacity is being expanded to 30,000 tonnes a year. Current output of ammonium sulphate of 20,000 to 25,000 tonnes is being used by Staatsmijnen.

East Germany

VEB Leuna Werke has been producing caprolactam at an annual rate of 8,000 tonnes. Capacity is being increased this year to 24,000 tonnes and subsequently will be increased to 35,000 tonnes. As a result of the greater outfall of ammonium sulphate—now about 120,000 tonnes—Leuna has cut back synthetic production and the available ammonia is to be used in ammonium nitrate manufacture.

Czechoslovakia

Strojo Import Polytechna of Prague at the end of 1960 concluded an agreement valued at $2.8 million with High Polymer and Petrochemical Engineering Limited of London to build a nylon-6 tyre cord works. The plant will be supplied by Hans J. Zimmer, Frankfurt,



and the Zimmer process will be used. No details of capacity have been released.

Output of an existing plant is reported at 2,000 tonnes a year caprolactam.

Rumania

Pilot plant trials using the Zimmer process have recently been successfully concluded and a 0.5 tonne a day plant is now under construction.

U.S.S.R.

The U.S.S.R. has concentrated on four synthetic fibres: Capron—a nylon-6 fibre, Anid—a nylon-66 fibre, Lavsan—a polyster, and Nitron—an acrylic fibre. In 1959, only nylon-6 was being produced on a commercial scale.

Recently built Capron (nylon-6) plants are Engels Fibre Combine in the Saratov region and the Riga Komsomol plant in Latvia. These plants have been producing nylon-6 since 1959 and use caprolactam obtained by the Schlach process. Due to have reached full output this year is the nylon-6 tyre cord facility at Barnaul. Other nylon-6 plants are now under construction at Mogilov, at Razdan in Soviet Armenia and at Chernigov in the Soviet Ukraine; this last-named plant was due to come into operation this year.

Caprolactam has been produced on a commercial scale in the U.S.S.R. since 1950 at a plant at Klin, near Moscow, which in 1959 had an annual capacity of just under 15,000 tonnes. The German Schlach process, based on phenol, is used at present.

The Kirovakan caprolactam plant which is now under construction is likely to use a U.S.S.R. developed irradiation process. Output from this plant will supply the new Capron plant under construction at Razdan. The Kiev Experimental Laboratories, however, have developed a new continuous caprolactam polycondensation process and it is believed that this new process may be employed at Kirovakan.

Caprolactam capacity is to be expanded at the Gubakha chemical plant in the Pernshaya region and at the Lisichansk chemical combine in Kiev by plants to be supplied by West Germany, under a trade agreement, comprising two 10,000 tonnes a year plants based on aniline (Zimmer process), a caprolactam distillation plant by Lurgi AG., and two 6-ton a day caprolactam continuous polymerization plants; they are expected to be in operation after 1967. Still in the planning stage is a projected caprolactam plant at Rustavi, where a nylon-6 plant will also be constructed.

Mexico

Celanese Mexicana S.A. has awarded a nylon-6 plant contract to Feldmuhle AG., of Rossbach, Switzerland, which will provide technical aid. The plant is to be erected at Octolan in Mexico and will include a caprolactam plant of 6,000 tonnes a year capacity. It is

expected that the Inventa/Emser Werke process will be employed.

Cicloamidas S.A., a subsidiary of three synthetic fibre producers, plans to build a 8,000 tonnes a year caprolactam plant by 1963.

South America

In Argentina *Ducilo S.A.I.C.* is the main nylon-6 producer. For its caprolactam production it employs a Zimmer plant and process. Other nylon-6 producers with caprolactam facilities are Extavia S.A., Hisisa Argentina S.A., and Prenyl S.A. In Peru, *Manfacturas de Nylon S.A.* has a nylon-6 caprolactam facility coming into operation.

Extavia S.A. is using the Zimmer process and is producing 25 tonnes of caprolactam a month. The plant is now being expanded and when the expansions are complete production will rise to 60 tonnes monthly.

ECONOMICS

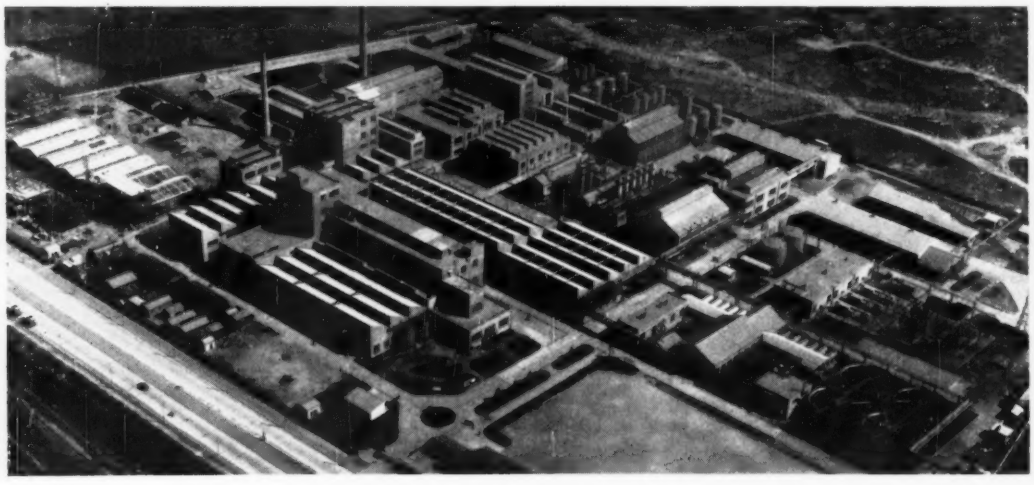
In all caprolactam processes at present employed ammonia is used to neutralize sulphuric acid and hence considerable quantities of ammonium sulphate are produced varying from about 2 tons to about 5 tons of ammonium sulphate per ton of caprolactam produced. This factor, coupled with the price obtainable for ammonium sulphate as fertilizer material, significantly influences the economics of the various available caprolactam processes.

Of these, the Snia Viscosa process has received favourable attention but, as yet, operating experience is not available. The price of the raw material—toluene—does not differ from that of benzene and the yield of caprolactam is reported to be about 70%. When royalties, which are said to be low, and initial payments are added to the general costs the Snia process does not, however, compare favourably with the process based on benzene and cyclohexane.

Also, the quantities of ammonia, sulphuric acid, and concentrated nitric acid required are greater than in the other processes. In its favour is the large output of by-product ammonium sulphate—5 tonnes per tonne of caprolactam—and the simultaneous manufacture of terephthalic acid—1.4 tonnes per tonne of caprolactam—which is obtained by oxidation of para-toluic acid, a by-product obtained during the nitrosylation stage.

The Zimmer process is reported to give better yields of cyclohexane and to produce caprolactam more cheaply than the Snia Viscosa process.

Integration of caprolactam manufacture into petrochemical production facilities will



Aerial view of the second nylon-6 plant of Toyo Rayon at Nagoyo

Based on a comparative study made in Japan, costs and material requirements of individual processes are as follows :—

Snia Process

Raw Materials	Requirement/ton of Caprolactam in kg. units	Cost/ton Caprolactam (£)
Toluene (35 yen/kg.)	1,160	40.0
Hydrogen (10 yen/cu.m.)	1,300 (cu.m.)	12.8
Ammonia (30 yen/kg.)	1,410	41.7
Sulphur (22 yen/kg.)	400	8.7
Oleum (9 yen/kg.)	2,900	25.7
Conc. Nitric Acid (35 yen/kg.)	800	27.6
Others	—	9.9
Total	—	**166.4**
Ammonium Sulphate (13 yen/kg.)	5,350	68.7
Difference	—	**97.7**

Benzene Process

Raw Materials	Requirement/ton of Caprolactam in kg. units	Cost/ton Caprolactam (£)
Benzene	1,195	70.8
Hydrogen	1,300 (cu. m.)	12.8
Ammonia	1,650	48.6
Sulphur	1,100	23.8
Oleum	1,250	11.1
Ammonium Bicarbonate	1,340	29.1
Other Materials	—	0.2
Total	—	**196.4**
Adipic Acid (120 yen/kg.)	200	23.6
Ammonium Sulphate	6,000	76.8
Difference	—	96.0

Cyclohexane Process

Raw Materials	Requirement/ton of Caprolactam in kg. units	Cost/ton Caprolactam (£)
Benzene	40	2.4
Cyclohexane (70 yen/kg.)	1,220	84.2
Ammonia	1,650	48.8
Sulphur	1,100	23.8
Oleum	1,250	11.1
Ammonium Bicarbonate	1,340	29.1
Others	—	0.2
Total	—	**199.6**
Adipic Acid	200	23.7
Ammonium Sulphate	6,000	76.9
Difference		**99.0**

Phenol Process

Raw Materials	Requirement/ton of Caprolactam in kg. units	Cost/ton Caprolactam (£)
Benzene (60 yen/kg.)	40	2.4
Phenol (107 yen/kg.)	1,150	192.7
Hydrogen	1,000 (cu. m.)	9.9
Ammonia	1,650	48.8
Sulphur	1,100	23.8
Oleum	1,250	11.1
Ammonium Bicarbonate (22 yen/kg.)	1,340	29.1
Other Materials	—	0.2
Total	—	**318.0**
Ammonium Sulphate	6,000	76.8
Difference	—	**241.2**

1,009 yen=£1

inevitably necessitate individual assessment of the processes in the light of their own raw material and production units. From the viewpoint of the nitrogen industry as a whole and the fertilizer producers in particular, the large output of by-product ammonium sulphate is a growing problem.

In terms of N content by-product ammonium sulphate from caprolactam manufacture compares favourably with synthetic material, but it has adverse colour and physical properties in that it tends to be greyish-pink and in the form of smaller-sized crystals. These properties in no way affect its suitability for use in mixtures.

In Japan there is already evidence of integration between caprolactam producers and manufacturers of nitrogenous fertilizers.

MITI has recently estimated demand for caprolactam as follows:—

Tonnes				
1961	1962	1963	1964	1965
50,400	57,750	66,150	75,100	86,100

By 1965 ammonium sulphate produced as by-product in Japan can be expected to amount to just over 300,000 tonnes. In the U.S.A. and Western Europe there has as yet been no evidence of integration except in some instances the same companies produce both materials, promoting rationalization of production plans. Notable examples are Allied, Chemical, Staatsmijnen, B.A.S.F. and, in due course, Imperial Chemical Industries Limited.

On the basis of known production plans for caprolactam, world output of ammonium sulphate production from this source will in 1962 be about 1.4 million tonnes—representing nearly 10% of world production of ammonium sulphate.

Grace's Metal Ammonium Phosphate Fertilizer

Development of metal-containing nitrogenous fertilizers—magnesium or ferrous ammonium phosphate—which will not burn, or impair roots or foliage, is announced by W. R. Grace and Company, New York, U.S.A.

Composed of 8% nitrogen, 40% phosphate and 24% magnesium oxide (8-40-0), the magnesium content is said to cause a slower release of nutrients and to prevent burning. Under laboratory conditions, Grace's research division found that seeds could germinate and plants could grow in the compound without the presence of soil. This metal-containing fertilizer is reported to be especially adaptable to tree seedlings, turf, citrus fruits, shrubbery and ornamental plants and farm crops.

The other metal-containing compound, ferrous ammonium phosphate (7-35-0), is primarily recommended for use in nursery beds, although it has proved equally effective in forestry applications.

Currently in semi-commercial production, magnesium ammonium phosphate is now priced slightly higher than conventional fertilizers. Is is claimed, however, that the extra cost involved is offset, because of the controlled nutrient release and non-burning properties, and the considerable saving in time and labour as individual applications may be large, and hence, fewer.

No Caking

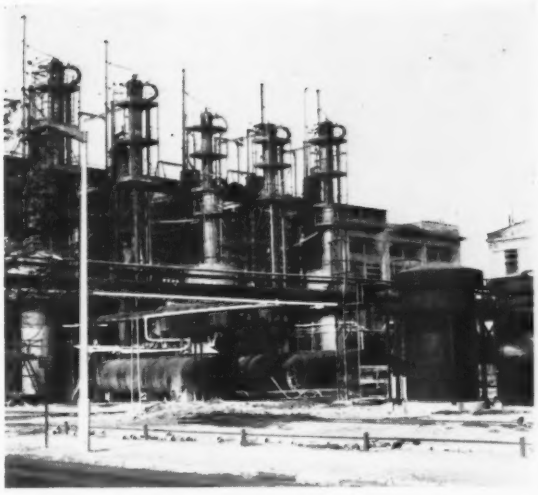
This new type of fertilizer does not cake and can be applied by hand or machine and is suitable for mixed fertilizer production.

The two compounds, as well as several other members of the metal ammonium phosphate family, have also been used successfully as pigments for enamels and ceramics.

It is not expected that magnesium ammonium phosphate fertilizers will find a large market. Research has shown that while magnesium does prevent burning, the slow release of nutrients could be a disadvantage. The main application for this fertilizer is expected to be in citrus fruit growing, for use in nurseries and magnesium-deficient areas.

High-purity Nitrogen for Ammonia Production Using H.R.I./C.J.B. Air Separation Process

Three plants for Tarnow works in Poland



A view of the F. Dzierzynski nitrogen plant at Tarnow at which works three C.J.B.-H.R.I. tonnage oxygen and nitrogen plants are to be installed

SINCE World War II, the separation of air into its principal constituents, nitrogen, oxygen and, to a lesser extent, argon, has developed into an operation involving large tonnages. With the building of plants capable of producing hundreds of tons a day of high purity nitrogen, the unit cost of this nitrogen has been reduced very considerably from its former level. Consequently, the production of nitrogen from air separation plants has become economic in comparison with the older methods, starting from coke and producing nitrogen from producer gas. Furthermore, if hydrogen is produced by the partial oxidation of a petroleum fraction, then the air separation plant, of course, will provide the oxygen required for this operation.

Tarnow Contract

Three tonnage oxygen and nitrogen plants are to be designed, supplied and installed at Tarnow, in the south of Poland, by Constructors John Brown Limited, the nitrogen to be used in the production of ammonia under a £2 million contract with Polimex, the Polish Government trade organisation.

The plants will be completed successively within a period of about five years and will have a combined output of nearly 1,000 tons a day of oxygen and more than 1,100 tons a day of nitrogen. It is planned to produce more than 1,000 tons of ammonia a day which will be used in the manufacture of nitrogenous fertilizers.

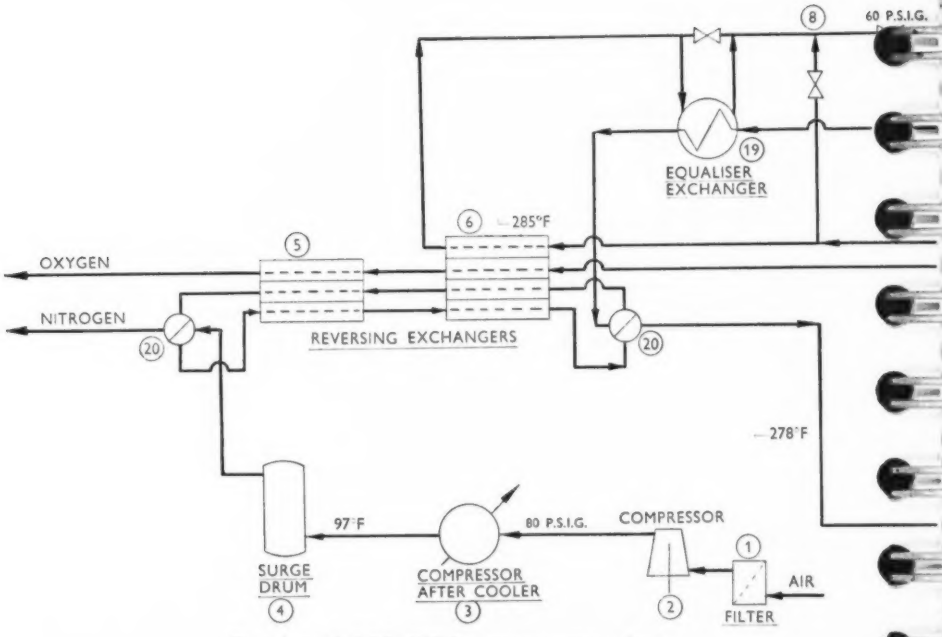
H.R.I./C.J.B. Process

The air separation process to be used has been developed in the U.S.A. by Hydrocarbon Research Inc. which will be closely associated with C.J.B. in the technical aspects of the project. These units, while operating on the familiar "double column" principle, incorporate certain features which have hitherto not been used in European air separation plants. In the conventional Linde-Frankl process, regenerators or cold accumulators provide the means of purification and cooling of the air to its liquefaction point.

Modern Technique

In the H.R.I. process application of modern engineering techniques has contributed to improve the efficiency, safety and flexibility of the air separation process.

Atmospheric air (1) is filtered to remove dust and fog, and then compressed (2) to 75 to 80 p.s.i.g. cooled (3) in a direct contact water-cooler, followed by a combination surge drum and entrainment separator (4). The cooled compressed air flows through a system of reversing time actuated valves, to reversing heat exchangers, where it is refrigerated to −280°F



Flowsheet of C.J.B.-H.R.I. tonnage oxygen plant

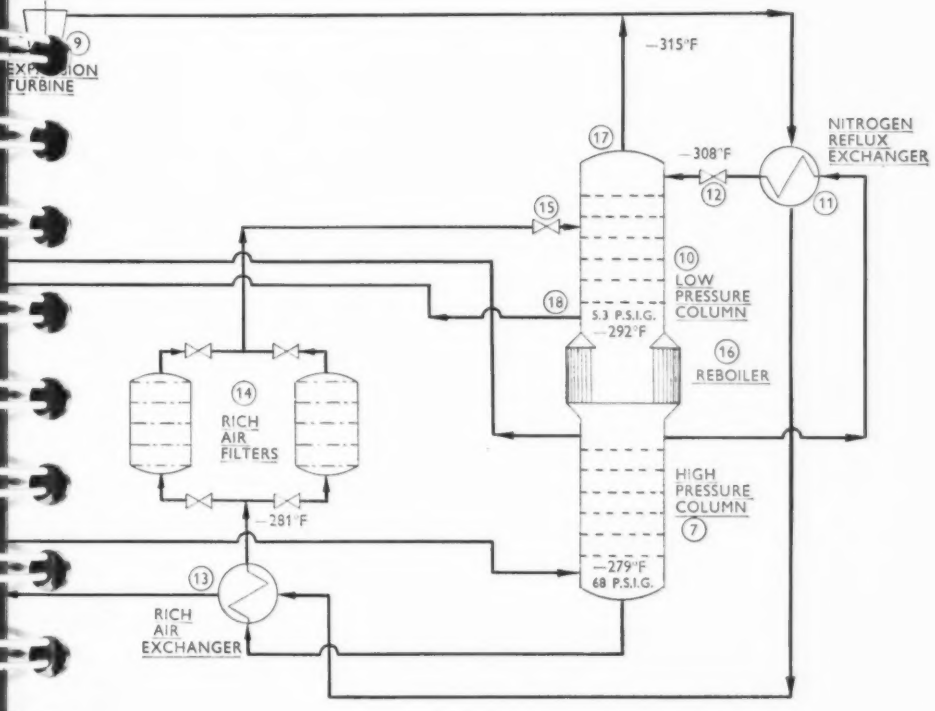
as it flows counter to the cooled nitrogen and oxygen streams leaving the air separation column. Water vapour and carbon dioxide are precipitated in the reversing exchangers.

Coincidentally with the cooling of the air refrigerated air enters at the bottom of the high pressure column (7) where the bulk of the air is liquefied and fractionated at 68 p.s.i.g. into an overhead liquid—"nitrogen reflux" and a bottom liquid "enriched air." Vapour in the column is washed by the liquid flowing over the lower traps and this collects any trace impurities entering with the air.

Use of Reversing Exchanger

Nitrogen equal in volume to 20 to 25% of the ingoing air is withdrawn from the top of the column and is reheated to −245°F by passing a portion of it back through the cooled end of the reversing exchanger (6) and mixing this portion with the remainder (8). This nitrogen stream is expanded to approximately 5 p.s.i.g. through an expansion turbine (9) to supply the supplementary refrigeration requirement of the system. Expanded nitrogen at −315°F joins the nitrogen vapour stream leaving the top of the low pressure column (10) and passes through the nitrogen reflux exchanger (11) sub-cooling nitrogen reflux from the top of the high pressure column to −308°F. This is then expanded through a valve (12) in the top of the low pressure column. Rich air from the bottom of the high pressure column is sub-cooled to −28°F by heat exchanger (13) with the nitrogen product and passed through silica gel absorbers which remove any possible impurities collected from the ingoing air and finally expanded through a valve (15) into the low pressure column.

The reboiler-condenser (16) is located between the low pressure and high pressure columns. Rising vapours in the high pressure column condense in the reboiler, by virtue of their high pressure (boiling point −286°F) furnish heat and boil the liquid oxygen at 292°F in the base of the low pressure column. Gaseous nitrogen (17) leaves the top of the low pressure column at −315°F. The gaseous oxygen product (18) free from CO_2 leaves the bottom of the same column just below the



first tray. Water flows from the base of the low pressure column out through the reversing exchangers.

Nitrogen Product

Nitrogen product, after heat exchange with the reflux stream from the high pressure column, is further heated to −285°F by exchange (19) with a part of the reheated nitrogen stream passing to the expander. This reduces the temperature difference between the nitrogen and the air at the cold end of the reversing exchanger to about 7°F. Nitrogen then flows out through the reversing exchanger counter current to the air entering the plant, at essentially atmospheric pressure and about 4°F below the temperature of the air leaving the reversing exchanger.

Every 15 to 25 minutes the flow paths of nitrogen and air through the reversing exchangers are switched by automatic valves (20) at either end of the exchangers. Oxygen product flows continuously through separate passages in the exchangers and its flow is never reversed. Oxygen thereby leaves the plant free from impurities. Reversal of flow between air and nitrogen means that nitrogen waste leaving the plant through the reversing process passes carries with it water and CO_2 previously deposited from the air entering the plant. Where especially pure nitrogen is required—as in ammonium synthesis—pure nitrogen product is withdrawn through non-reversing passes and so remains uncontaminated.

Design Features

Air is compressed only to a low pressure in turbo-compressors and this never comes in contact with lubricated surfaces by which it might be contaminated by oil. As high pressure is not used there is no necessity for chemical purification and all impurities are deposited in the reversing exchangers. When high pressures are required for extra refrigeration pure nitrogen is compressed in a non-lubricated compressor, so that it is uncontaminated. As refrigeration is performed by turbo-expanders contact with oil is avoided.

C.J.B.-H.R.I. low temperature plants for nitrogen or oxygen feature

- High on-stream time
- No shutdown for defrosting
- High flexibility
- Safe and reliable
- Low maintenance costs
- No joints in cold box
- All aluminium-stainless steel construction

If necessary a portion of the nitrogen, and the oxygen, are withdrawn from the system through non-reversing passes of the exchangers, so that deposited CO_2 and water vapour are not picked up. The fraction can thus be obtained in a state of highest purity.

Plant Construction Features

Because of their excellent mechanical properties at low temperatures all parts of the plant within the "cold box" are constructed of aluminium alloy or stainless steel. Argon-arc welding is used for all joints, except at main valves, to avoid flanges and jointing materials which might develop leaks under low temperature stress.

For bonding aluminium to stainless steel when junction between these two materials becomes necessary a special process has been developed. Operating valves have spindles and packing glands extending outside the cold box. Equipment within the cold box is stated to require practically no maintenance and a special feature is that the plant can be operated for very long periods—up to $2\frac{1}{2}$ years—without the necessity for defrosting.

The unit construction of heat exchangers tanks and the design of column employed have been found to give greater flexibility in operation than the use of regenerators and sieve plate columns.

By virtue of the provisions for continuous and safe operation the need for stand-by equipment and reserve plant is reduced to a minimum and C.J.B.-H.R.I. suggest that a large single unit can be installed to provide all requirements rather than to divide the load between two or more units for the sake of continuity of supply.

H.R.I. Tonnage Air Separation Plants Designed and Built Since 1946

2 x 1,000 T/D O_2 — Carthage Hydrocol, Brownsville, Texas.
1 x 800 T/D O_2—Tennessee Chem. Co. (In construction).
1 x 600 T/D O_2—Monsanto Chemical Co., Texas City, Texas.
3 x 300 T/D O_2; 360 T/D N_2—Polimex, Poland (In construction).
2 x 200 T/D O_2—Wheeling Steel Corp., Steubenville, Ohio.
1 x 200 T/D Oxygen—McCarthy Chemical Co., Winnie, Texas.
2 x 100 T/D N_2—Atlantic Refining Co., Philadelphia.
1 x 150 T/D O_2; 150 T/D N_2 — Taiwan Fertilizer Co., Formosa.
1 x 150 T/D O_2; 150 T/D N_2 — Government of Korea.
1 x 50 T/D O_2; 15 T/D N_2; 1.4 T/D Argon (all produced as liquid) — Chemetron Corp., Conshohocken, Pa.
1 x 45 T/D O_2—Bethlehem Steel Co., Vernon, Cal.

T.V.A. Process for Pan-Granulation of Nitrogen Fertilizer

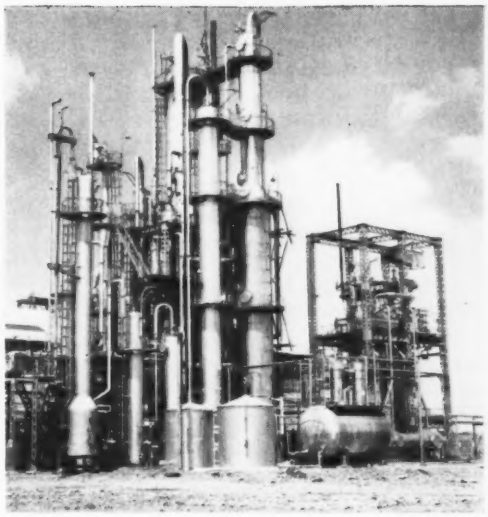
DEVELOPMENT engineers of Tennessee Valley Authority have obtained promising results in pilot-plant trials of pan-granulation of nitrogen fertilizers. The process involves spraying a concentrated solution of fertilizer salts on a bed of material in the inclined pan. The product is then dried and screened, and the undersize is returned to the pan for further processing. TVA states that product with good physical properties is made by this procedure.

Spraying of concentrated solution on a dry bed in the pan-granulator is a unique application of the equipment. TVA reports that the unusual classifying action of the pan makes it ideally suited for the production of certain granular fertilizers. It is estimated that the process should have advantages over the prilling process because of a lower investment cost.

Trials will now be carried out on a larger scale to obtain more engineering data, particularly capacity data.

Current Developments in Japan's Nitrogen Industry

New ammonia, ammonium sulphate and nitric acid plant projects



The new ammonium sulphate-from-natural gas plant at Nagoaka Works of Nissan Chemical Industrial Limited which came into operation in June. Annual plant capacity is 16,000 tonnes of ammonia and 9,900 tonnes of ammonium sulphate

DURING the past eight to ten years Japan's nitrogen industry expended much effort and made great strides and in this period achieved a substantial reduction of primary nitrogen production costs. As indicated below, in 1960 32% of Japan's ammonia production of about 1.3 million tonnes NH_3 was derived from solid hydrocarbons and 57% from gaseous or liquid sources. By 1963 the latter will provide the basis of 94% of total ammonia production, which can be expected to have risen by at least 15% while the use of coal and coke will account for only 3.5%.

New Ammonia Facilities

In this connection it is significant that construction of new ammonia facilities has been announced within the last few months by most of the leading Japanese ammonia producers.

Toyo Koatsu Industries, at its Sunagawa, Hokkaido, plant, will use a mixed combustion process of crude oil and coal. Although a crude oil gasification process is also under consideration at Toyo Koatsu's Omuta plant, construction of a Texaco unit of 299,900 tons capacity was completed in June and waste gases from fuel refining now replace the present coke-oven gas process. At Miike Gosei, however, Toyo Koatsu uses coke-oven gas from which 112,200 tonnes ammonium sulphate has been manufactured. Tohoku Fertilizer Company at Akita is erecting a 100 tonnes NH_3 a day Chemico ammonia synthesis unit which will be based on natural gas, and Nihon Suiso at Onahama is changing over to a crude oil gasification process using an improved Koppers process, whereby ammonia capacity will be increased to 47,100 tonnes NH_3.

Changes in H_2 Sources of Ammonia

Hydrogen source	1960	1963
Electrolysis	11%	2.5%
Coal and coke	32%	3.5%
Liquid and gaseous sources ...	57%	94%
Crude oil	25%	45%
Coke-oven gas	10%	18%
Natural gas	15%	21%
Refinery and waste gas ...	7%	10%

Natural Gas as Raw Material

Toyo Gas Chemical Company of Tokyo is increasing ammonia capacity at Niigata to 100 tonnes NH_3 a day based on natural gas, while in January this year Nissan Chemical completed an ammonia-from-natural-gas plant.

Toa Gosei Chemical Company is enlarging its synthetic ammonia facilities at Nagoyo to produce 100 tonnes NH_3 a day which will be supplied to Toyo Rayon and Tokai Ammonium Sulphate Industries Company. The latter company will operate a Shell-type crude oil gasification plant and the 87,000 tonnes capacity electrolytic source plant will be sold

to the adjacent Mitsubishi Petrochemical Company.

Tokai Ammonium Sulphate Industries is to enlarge its Fauser-type ammonia synthesis facilities, and capacity at its Yokkaichi works is envisaged at 100 tonnes NH_3 a day. Befu Chemicals Company has completed a new ammonia synthesis unit of 40,000 tonnes NH_3 capacity at Himeji which is based on coke-oven gas.

Ammonium Sulphate Production

Although under current nationalization measures, much synthetic ammonia capacity is being switched from the production of fertilizer ammonium sulphate to urea, there are simultaneously a number of projects for ammonium sulphate production designed to fill anticipated fertilizer needs. In most instances the projects base ammonia synthesis on coke-oven gas.

Ammonia synthesis facilities of three major iron and steel companies are to be expanded and Yawata Iron and Steel in association with Shin Nippon Chisso Hiryo (Kyushu Kagaku), Fuji Iron and Steel with Befu Chemical (Seitetsu Kagaku), and Tokai Iron and Steel with Toa Gosei and Toyo Rayon will produce ammonium sulphate.

This expansion is said to be required to meet the demand for ammonium sulphate in 1963—estimated at 830,000 tonnes—and for which present production facilities are insufficient.

By 1962 when Nippon Kokan plans to complete the new steel plant 46 million cubic metres of coke-oven gas will be surplus. The company plans to produce daily 100 tonnes urea, and 88 tonnes ammonium sulphate.

Kyusha Kagaku, the joint company formed by Yawati Chemical and Shin Nippon, will produce 100 tonnes of ammonia daily at its recently completed plant at Tobata.

Sietetsu Kaguka, the joint company formed by Fuji Iron and Steel, Sumitomo Chemical and Befu Chemical is constructing an ammonia synthesis unit and an ammonium sulphate plant in Himeji, with an annual production capacity of 230,000 tonnes ammonium sulphate. It is due to be completed in September this year.

New Nitric Acid Plants Planned

Nissan Chemical Company is expected to bring its 2,000 tonnes a month nitric acid plant at Toyama on stream shortly. The new Fauser process will be employed and the nitric acid produced will be sold. An existing 1,200 tonnes-a-month plant will be dismantled. It is expected that because of the growing demand for nitric acid, i.e., for isocyanates, caprolactam, etc., the new plant will be expanded shortly to 3,000 tonnes a month.

To meet the projected increased production of caprolactam and toluene diisocyanate, Mitsubishi Chemical Company is also planning to increase nitric acid capacity by 6,000 tonnes a month, using either the new Fauser-Montecatini process or the Kuhlmann process.

Mitsubishi Chemical has two plants for production of nitric acid, one with a rated capacity of 4,200 tonnes a month of 60% HNO_3 and using the Frank Caro process and the other of 3,000 tonnes a month of 60% HNO_3 using the new Fauser process.

Nitric Acid Demand Forecast

	1960	1961	1962	1963
Industrial Explosives	8,658	8,900	9,300	9,600
Celluloid	4,535	5,730	5,800	5,700
Nitro Cellulose	5,557	6,170	6,790	7,510
Dyestuffs	17,074	19,200	20,700	22,400
Toluene diisocyanates	—	2,700	10,200	14,700
High-Analysis Nitrogen Fertilizer	17,241	17,600	22,200	28,000
Ammonium nitrate (technical)	20,937	23,000	25,000	28,000
Ammonium nitrate (fertilizer)	24,918	25,000	25,000	28,000
Others	36,077	38,700	41,400	46,700
Domestic Demand Total	**134,997**	**147,000**	**166,400**	**187,800**
Export Total	**1,275**	**1,300**	**2,000**	**2,000**
TOTAL	**136,272**	**148,300**	**168,400**	**189,800**
Production	140,052	148,300	168,400	189,800
Production Capacity	143,800	204,800	232,400	231,400
% Ratio of Operation	97.4	72.4	72.4	81.6

Construction of the new plant will be started this year and when it comes into operation the 4,200 tonnes a month Frank Caro plant will cease to operate.

Nitric Acid Demand Forecast

The Japanese MITI (Ministry of Trade and Industry) has indicated that this year production capacity, in terms of 98% nitric acid, is 204,800 tonnes and this is expected to increase to 231,400 tonnes by 1963 when actual production is expected to reach 189,800 tonnes. Only 72.4% capacity is expected to be utilised in 1961 and 1962.

Present and future Japanese nitric acid demand is broken down by MITI as indicated in the table on the previous page.

Ammonium Thiocyanate as Catalyst for Acrylic Polymers

CROSS-LINKING of thermosetting acrylic polymers can be effected using ammonium thiocyanate as a catalyst. Curing takes place at low temperature; even at room temperature if a long curing period is possible. So far satisfactory results have only been obtained with unpigmented systems, but it appears that the catalyst has an adverse effect on pigment dispersion.

Using Rhoplex AC-200 and Rhoplex AC-201, two thermosetting acrylic polymers made by Rohm and Haas Company Philadelphia 5, U.S.A., the unpigmented films formed are water clear, even in the presence of ammonium thiocyanate; it is suggested therefore that the systems should have application possibilities for coating products such as construction materials, chromium-plated plumbing and piping fixtures, and various items made from polished brass, bronze, copper or aluminium.

Optimum results appear to be given by 2% of catalyst. The catalyst can be stirred in as a dry powder, but addition as a water solution is preferable. After the catalyst is added no further pH adjustment should be made. Pot life of the catalysed material is 5 to 6 hours, or more if less catalyst is used. Pot life can also be increased by adjusting the pH with ammonia or volatile amine, but the catalysing efficiency is lowered.

When using ammonium thiocyanate as a catalyst, care has to be taken to avoid contamination with iron, which produces a pink colour. This colour change is, in fact, a qualitative test for ferric iron in acid solution.

Vermiculite for Absorption of Nitrous Fumes

CONCENTRATIONS of the order of 0.1% total nitrogen oxides calculated as NO_2 are effectively absorbed and reduced to about 0.005% by passing exit gases through a 2ft. bed of $\frac{1}{8}$ to $\frac{3}{8}$ inches exfoliated vermiculite impregnated with a solution of 5% sodium carbonate and 5% potassium permanganate. The latter reagent oxidizes nitric acid to the absorbable higher oxides. After impregnation the bed remains active for periods of up to two weeks, clean air being passed between blasts of nitrous waste gas to minimize decomposition of the permanganate.

The method was originally developed to remove toxic nitrous fumes from the air following blasting with nitro-explosives in mines. Such fumes consist of nitrogen oxides, including nitrogen dioxide/tetroxide (NO_2/N_2O_4).

In a fume extraction plant, the bed was successfully regenerated repeatedly for over a year. The size of beds ranges from 120 to 300 sq. ft. in area*, corresponding to a throughput capacity of 6,000 to 15,000 cu. ft./min.

* Rabson, S.R. Industrial Chemist, May 1961

World Nitrogen Capacity to Rise to 22 Million Tonnes N by 1965

DURING the past three years the growth of world consumption of fertilizer and technical nitrogen has progressively narrowed gaps between available capacity and actual production to the extent that in a number of major producing countries operations at the height of the fertilizer season effectively employ and at times even exceed the rated ammonia plant capacity of the industry. The outstanding example is the U.S.A. where in the latter part of the 1950's, after a major expansion phase, as much as one-third of available capacity was idle whereas from March until May of this year production exceeded installed capacity of 5.4 million short tons NH_3 by over 3%.

World nitrogen industry, which at the start of 1961 had instaled capacity of 14.5 milion tonnes N, stands at the threshold of a new expansion phase which by 1965-66 can be expected to result in installed plant capacity reaching 22 million tonnes N, an increase of 7.5 million tonnes N.

Underdeveloped Countries

A proportion of this new capacity is, of course, represented by plants being built under development plans in the lesser developed countries. These projects should strictly be considered apart from the volume of new plant constructions now under way in the majority of the established producing countries, mainly because the decision to build is in most instances not of recent date and their impact on world supplies is therefore taken into account by those projecting new plants now. One of the features of many of these projects is the discrepancy between planned and actual completion dates and whereas known projects due to be completed by 1965 total about 2.2 million tons N it is estimated that only about 1.3 to 1.4 million tons will actually be on stream by this date. Plant projects in South-East Asia and the Far East amount to 1,230,000 tonnes N, those in Mediterranean countries 510,000 tonnes N, in Africa 150,000 tonnes N and Central and South American 340,000 tonnes N.

Communist Countries

New plant projects in the Communist countries of Europe and the Far East are at least as great if not greater than in the rest of the world, as all these countries are determined substantially to expand their relatively low level of N production in the shortest possible time and to provide adequate supplies of nitrogenous fertilizers to their agriculture in accordance with development plans.

China alone has announced plans for up to 1.5 million tonnes N by 1965, although it is not expected that more than 500,000 tonnes N new capacity will actually become available. The U.S.S.R. is believed to be planning the installation of 750,000 tonnes N and in Eastern Europe, where Poland with projects of some 800,000 tonnes N is the most prominent, plant projects total about 1.7 million tonnes N. The bulk of the developments is due for completion after 1963 and some not before 1967. Whereas in 1960-61 Communist countries are estimated to have produced about 2.3 million tonnes N, it is expected that their output by 1965-66 will reach 4.0 to 4.5 million tonnes N.

Western Europe and North America

Although developments in most of the countries outlined above are new or intended to augment the existing modest levels of production, the expansion foreshadowed in Western Europe and North America is being undertaken by major established industries which at present account for 90% of world supplies. Moreover, the majority of companies engaged on new projects have had to bear competitive pressures of recent years and their

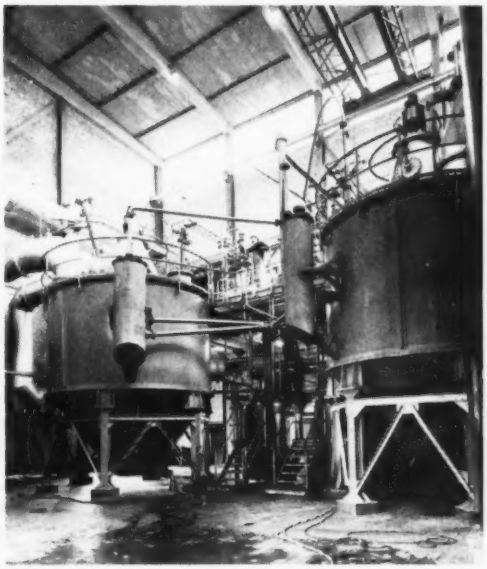
decision to expand would seem to be based not only on the apparent trend of rising demand at home and overseas but also on the ability to produce competitively and profitably. In this respect the two dominant factors are the cost of hydrogen and the incidence of plant cost on the end products. In an increasing number of projects these requirements can only be satisfied by integrating the nitrogen plant in a petrochemicals complex more often than not based on a cheap source of natural gas.

U.S.A.

The largest expansion is, not unexpectedly, foreshadowed in the U.S.A., where projects now in hand or about to be started will raise current capacity by 800,000 short tons NH_3 by the end of 1963. Beyond this date no further plans have been announced, but it is thought by a number of prominent members of the U.S. nitrogen industry that capacity will have to be advanced perhaps up to 7.5 million short tons NH_3 to meet requirements in 1965-66.

Western Europe

In Western Europe installed capacity at the start of 1961 totalled about 4.8 million tonnes N and Western Germany, with plant totalling about 1.55 million tonnes N, is the largest individual producing country and the second largest in the world. Yet Western Germany and also Belgium, are the only two major producers not at present envisaging expansion of production facilities. While both depend on export markets for an outlet for about one-half of their production of fertilizer nitrogen it is not thought that this factor alone would account for the time being for the absence of expansion plans. The endeavour to modernise plant and accelerate the change of the hydrogen source from coke-oven gas to oil, refinery or natural gas, may be considered by these two industries to be the extent of profitable investment.



Ammonium sulphate plant of Oxelosunds Jarnverk A/B, Sweden. Capacity is 3,500 tonnes product a year

In Italy a number of new projects are either in progress or anticipated and new capacity of up to 150,000 tonnes N can be expected on stream before 1965 although in turn some old plant is likely to be taken out of production. France, where plants are to raise production capacity to 1.4 million tonnes N, and the Netherlands, are the main focus of expansion. French development, which will nearly double the capacity available in 1960, may reach fruition as early as 1963. In the Netherlands the availability of natural gas in the Delfzijl area has promoted plans by Mekog/K.N.Z. and Staatsmijnen respectively, and while initially each appears to have envisaged a 300 tonnes a day N plant, an agreement to build jointly a single plant of perhaps 750 tonnes a day N may be reached. The possibility that the petrochemicals plants projected in Holland by U.K., German and U.S. companies may eventually include ammonia plants based on hydrogen sidestreams, cannot be excluded.

In the U.K. new capacity of 218,000 tons N, based on naphtha and refinery gas, will become available when Imperial Chemical Industries Limited's and Fisons Limited's projects mature, and in Eire also construction of a major plant is foreseen.

In Scandinavia, in addition to expansion and new construction totalling over 80,000 tonnes N by Norsk Hydro and the Norwegian State, a major nitrogen plant is to be built

at Grenaa in Denmark, and eventually the new petrochemicals plant of Esso in Sweden may also include ammonia production facilities. Available capacity in Western Europe in 1965 should reach 6.2 milion tonnes N.

Japan

The large-scale rationalisation of production facilities, resulting on the one hand in an increased proportion of ammonia being based on oil, natural and oil refinery gas, and on the other in the expansion of urea and complex fertilizer production, partly at the expense of ammonium sulphate, is accompanied by a substantial plant construction programme. From the present level of 1.17 million tonnes N, plant capacity is to be raised to 1.5 to 1.6 million tonnes N by 1965.

Competitive Supplies

Although worldwide, the expansion trend is tempered by economic considerations. A typical example is Lebanon, where plans for an 80,000 tons N plant were abandoned when projected costs of production were set against the prices, albeit highly competitive, of material imported from major suppliers in Italy and West Germany. The present phase of expansion is not viewed with the alarm which was evident in the 1950's, mainly because it was seen that, especially in less developed countries, new constructions and domestic supplies of fertilizer nitrogen stimulated consumption and generally did not adversely affect imports from the major suppliers. In Europe and Japan uncertainty is, however, focused on the impact on the level of export sales to countries which receive I.C.A. aid for supplies from "limited world sources" and in the medium term on the possibility of supplies from Communist countries entering traditional export markets and causing prices to decline. The overriding sentiment, however, is cautious optimism of steadily increasing consumption of fertilizer and technical nitrogen which the major world producers plan to meet from production facilities operating economically and profitably and to this end the present phase of new constructions is generally thought justified.

SUPPLY

U.S.A.

Anhydrous ammonia production, which rose to a new peak in May of 477,508 short tons NH_3, is being maintained at a level of 9% to 10% above that prevailing last year. During the period of peak operations—March to May—plants are reported to have worked at over 100% of rated capacity. During the first half of 1961 output of 2,655,905 short tons NH_3 was 8.1% greater than in the corresponding period of 1960, whereas the output of 5.01 million short tons NH_3 in the year ending 30 June 1961 was about 300,000 short tons NH_3 (6.2%) greater than in the preceding year.

Consumption of fertilizer nitrogen was hampered by unfavourable weather in the spring and it is estimated that in 1960-61 it will have totalled only about 2.85 million short tons, an increase of less than 3% over the preceding year, but it is expected to continue growing by 4.5% to 6% per annum.

Ammonium sulphate output improved in the second quarter of 1961 especially in June, when at a level of 130,152 short tons it was higher than in any one month since April 1960. Nevertheless, total output of 1.38 million short tons during the fertilizer year 1960-61 was 183,000 short tons less than in 1959-60.

	January to June	
	1961	1960
	short tons	
Anhydrous ammonia ...	2,655,905	2,459,203
Ammonium sulphate :		
Total	709,035	833,236
Synthetic	427,405	453,066
By-product	281,630	380,170
Ammonium nitrates (100% NH_4NO_3) ...	1,591,793	1,537,284
Nitrogen solutions (100% N)	505,995	474,909
Nitric acid (100% HNO_3)	1,660,095	1,648,333

The fertilizer season this year has lasted well into July and whereas the late spring demand for ammonium nitrates tailed off sharply, that for urea was exceptionally strong, boosted by increased requirements for feed grade material. Demand for nitrogen solutions also continued longer than usual.

New Plants

Spencer Chemical Company, Kansas City, Mo., is to follow its major expansion in non-

pressure nitrogen solutions by providing nitric acid for the new $7 million potassium nitrate plant at Vicksburg, Miss., for Southwest Potash Company.

The new fertilizer, to be produced by Spencer Chemical at the new 50,000 short tons a year fertilizer unit at its Jayhawk Works, near Pittsburg, Kansas, will contain 30% nitrogen and 10% phosphorus. Construction of the new facility is due to be completed in time for production to be started during the 1962 fertilizer season.

Hawkeye Chemical Company has been formed jointly by Swift and Company and Skelly Oil to build and operate a $10 million, 300 s.tons-a-day ammonia plant near Clinton, Ia. Principal products will be ammonia, nitric acid, nitrate solution, ammonia nitrate, urea and nitrogen solutions.

Monsanto Chemical Company is to build a 200 s.tons-a-day ammonia unit near Muscatine, Iowa. The plant—Monsanto's third*—will arise adjacent to the 15,000 s.ton anhydrous ammonia terminal already under construction on a site four miles from Muscatine, on the Mississippi River. Erection is to start in October and completion is scheduled for autumn 1962. The new facility will supply the U.S. Mid-West fertilizer market.

Canada

Ammonia and ammonium sulphate production continued at a high level at Sherritt Gordon Mines Ltd., Toronto, Ontario, during the second quarter of 1961 in order to meet sales commitments.

Construction is to start shortly on Eastern Canada's first diammonium phosphate plant. It will be built by Cyanamid of Canada Limited at its Welland Plant, Niagara Falls, Ont., at a cost of more than $2 million in its first stage. Granular triple superphosphate will also be produced at this plant.

Ammonia is already produced at Welland but expansion of facilities will be necessary as a result of the decision to produce diammonium phosphate. Completion of the first phase of the expansion programme is expected by mid-1962.

United Kingdom

Production of fertilizer nitrogen in April totalled 38,300 tons N and in May 39,400 tons N. Output during the fertilizer year 1960-61 is expected to total about 440,000 tons N, an increase of 10%. Production of ammonium sulphate is estimated to have remained unchanged or receded slightly from the level attained in 1959-60 and that of complex fertilizers to have increased modestly; the bulk of the increased output was in the form of ammonium nitrates. Deliveries to the home market continued at a high level throughout May, and for the year 1960-61 are expected to total 455,000 tons N, an increase of nearly 10%. Demand for technical nitrogen continues increasing and is estimated at present at an annual rate of 165,000 tons N.

Cyanamid of Great Britain Limited has now on stream its plant for melamine crystal at Gosport, Hants. Annual output is expected to be about 3,000 tons.

Western Germany

Production of fertilizer nitrogen in May totalled 102,846 tonnes N and that of technical nitrogen 16,901 tonnes N. The latter represents a surprising drop of about 2,700 to 3,000 tonnes N compared with preceding months. Production of primary nitrogen in 1960-61 is expected to total about 1.29 million tonnes N, an increase of 10% compared with the preceding year.

Domestic deliveries of fertilizer nitrogen in May declined severely to 25,697 tonnes N, 32% less than in May 1960, and total deliveries during the fertilizer year are expected to be fractionally lower than in 1959-60. Exports are expected to total over one-half million tonnes N, an increase of 5 to 6%. Stocks of fertilizer nitrogen of 198,847 tonnes at the end of May were about 66,000 tonnes N above the corresponding level in 1960.

Consumption of synthetic fertilizers in Western Germany during the 1960-61 fertilizer season are reported at 569,000 tonnes N, 544,000 tonnes P_2O_5, 804,000 tonnes K_2O. These compare with 1959-60 consumption of 561,000 tonnes N, 630,000 tonnes P_2O_5, 829,000 tonnes K_2O.

Permission has been given to the Deutsche Ammoniak-Vereinigung by the West German Cartel Bureau to continue in existence until at least 31st July, 1964. Permission was granted on 12th July, 1961, and was based on a

* El Dorado, Ark., and Luling, La.

decision taken on 15th December, 1960, and revised on 24th February, 1961.

Scholven Chemie AG., of Gelsenkirchen, in 1960 produced 61,000 tonnes N of liquid ammonia, or 41% more than in 1959. The company also produced 82,000 tonnes of calcium ammonium nitrate—an increase of 82%. Production of fertilizer increased to 128,000 tonnes from 75,000 tonnes (71% increase) but this is still below the estimated plant capacity of 180,000 tonnes.

Ruhr-Stickstoff AG., of Bochum, has developed a new nitrogenous fertilizer for use on pasture—Rusti-magnesia. The fertilizer contains 20% N (two-thirds as ammonia) and 8% magnesium oxide and 0.4% copper in the form of sulphates.

France

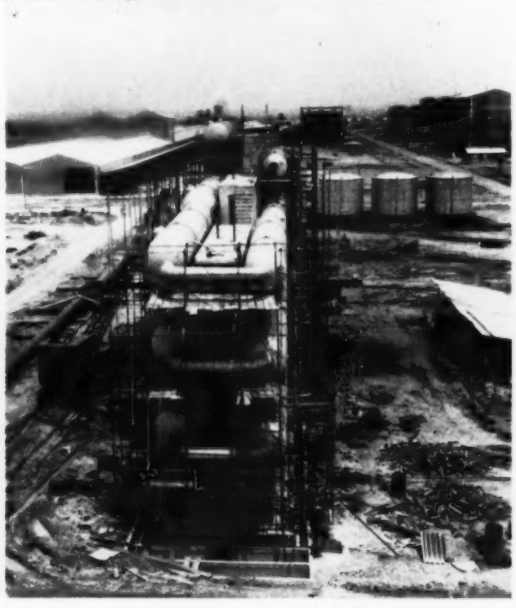
Ammonia production, which in June totalled 67,000 tonnes NH_3, is being maintained at a high level. The main emphasis continues on production of ammonium nitrates but urea and complex fertilizer production is also prominent.

Output of ammonia at the Pardies plant of Soc. Aquitaine Chimie is increasing progressively and is providing the bulk of the requirements for the manufacture of ammonium nitrate and urea by Azolaq.

Etablissements Kuhlmann, of Paris, with E.I. Du Pont de Nemours and Company, of Wilmington, Delaware, U.S.A., is forming a new company, Dekachimie, which will manufacture and sell isocyanates. Dekachimie will build a plant at Kuhlmann's existing La Madeline plant*.

A plant for the production of granular ammonium nitrate is to be built by Ammonia S.A. at its Wingles plant, Pas-de-Calais. To be engineered and constructed by Societe Belge de l'Azote et des Produits Chimiques du Marly, (S.B.A.) of Liege, Belgium, the new unit will use the S.B.A. process, and have a daily capacity of 150 tonnes of ammonium nitrate.

Contrary to the general trend, domestic prices in France have increased slightly. Most prices are ½% higher and the new urea prices are about 2% higher.



Left: **A view of the nitric acid plant of Industrias Colombianas de Fertilizantes under construction at Barrancabemerja. At the *top right* is the house and the water-cooling towers. *Right* the conversion plant***

* NITROGEN No. 12, July 1961, Page 34.

Spain

Union Quimica del Norte de Espana has applied for authorization to construct a factory at Zaragoza, to produce complex fertilizers and 60,000 tonnes of ammonium nitrate. Machinery and equipment worth 420 million pesetas will be imported from West Germany.

Netherlands

For the first half of 1961 nitrogen production of Staatsmijnen of Geleen amounted to 118,000 tonnes, compared with an output of 113,000 tonnes for the corresponding six months in 1960.

A high level commission appointed by the Ministers of Economic Affairs and Finance of the Netherlands is to study the legal status of Staatsmijnen, which is run as a nationalised industry under a board responsible to the Minister of Economic Affairs. The commission has been asked to advise the Government whether Staatsmijnen should be given corporate status and, if so, to make recommendations on the form to be chosen. The Managing Director of Staatsmijnen, Mr. H. H. Wemmers, who is a member of the new commission, earlier this year stated he was in favour of turning Staatsmijnen into some form of company. The Supervisory Council of the Mines is understood to concur with his view.

Soc. Montecatini has concluded an agreement with Delta Chemie, the recently-formed wholly-owned subsidiary of three large Dutch agricultural co-operatives*, which manufactures fertilizers, whereby the Italian company will take part in Delta Chemie's operations at its Vlaardingen plant. At the same time the Dutch company will have an interest in Compagnie Neerlandaise de l'Azote, a Montecatini subsidiary at Sluiskyl, which also produces nitrogen fertilizers.

Norway

Sales of nitrogenous products by Norsk Hydro in the period July 1960 to June 1961 accounted for 74% of the total turnover which was at the record level of about 600 million crowns (£30 million) or 40 million (£2 million) higher than that recorded for 1959-60.

Norsk Hydro has announced plans to expand ammonia capacity at Rjukan by 12,000 tonnes N. According to Mr. Nordhagen, a director, the additional capacity is due on stream in the early summer of 1962 and most of the resultant output will be despatched to Eidanger for conversion to fertilizer and technical nitrogen products.

Greece

Nitrogen and ammonia are included in the list of items, for which foreign trade tariffs are to be reduced over a 22-year period under the agreement between Greece and the Common Market countries. This period is to be composed of a 10-year interval and a 12-year tariff levelling period similar to the period usual under the original six-country common market treaty.

Agricultural co-operatives in Kalamata, Greece, have decided to erect a synthetic fertilizer plant at a site as yet unknown. The plant will be operated by a joint stock company to be set up by the co-operatives themselves. Long-term credit from abroad is hoped for in order to equip the plant. Hellenic Fertilizers and Chemical Company, of Athens, is to build a new fertilizer plant at Kavalla in Northern Greece, and the company also plans to modernise its plant at Drapetsona, Piraeus. This development programme is to be carried out in co-operation with the Greek National Bank and Saint Gobain of Paris, France.

Turkey

Imports into Turkey of most agricultural and industrial chemicals have been liberalised.

COMMUNIST COUNTRIES

East Germany

Exports of nitrogenous fertilizers from East Germany in the period 1953-59 were:—

Year	Tonnes N	Year	Tonnes N
1953	50,860	1957	82,564
1954	62,633	1958	95,633
1955	83,189	1959	102,272
1956	89,621		

Negotiations are said to be taking place for the exchange of East German synthetic fertilizers for 100,000 tonnes of Syrian barley.

An explosion which occurred on 24 May, 1961 at the Leuna-Werke AG. chemical combine in East Germany will this year result in a considerable fall in planned output of

* NITROGEN No. 9, January 1961, Page 37.

nitrogen products. Ammonia production alone is reported already some 2,240 tonnes "in arrears."

Poland

Tarnow nitrogen plant* is to be expanded by 1967 at a cost of some 5,400 million zloty. This year (1961), annual production at the plant is expected to be 4,800 million zloty. Besides the production of 342,000 tonnes N the Tarnow plant will produce 8,000 tonnes of caprolactam (40,000 tonnes ammonium sulphate) and 12,000 tonnes acrylonitrile.

Three tonnage oxygen and nitrogen plants worth £2 million are to be constructed in Poland by Constructors John Brown Limited, of London. The plants are to be completed successively within a period of five years and will have a combined output of nearly 1,000 tonnes a day of oxygen and more than 1,100 tons a day of nitrogen. Sufficient oxygen and nitrogen will be produced to allow for an output of 1,000 tonnes a day of ammonia.

In 1960 Polish nitrogenous fertilizer output amounted to 270,000 tonnes N. In 1965 production is expected to be 464,000 tonnes N.

Yugoslavia

An order for a £5 million fertilizer plant for Yugoslavia is being negotiated by Yugoslav officials and a Dutch engineering concern, believed to be Werkspoor N.V.

In the meantime, Societe Belge de l'Azote et des Produits Chimiques de Marley (S.B.A.) of Liege, Belgium and D. Bonaldi S.p.A. of Crema, Italy, have concluded an agreement with Proizvodnja Nafte whereby plant for the production from natural gas of gas destined for a methanol production unit will be supplied.

The plant is to be designed by the Engineering Division of S.B.A. and will use the S.B.A.-H.T. process, jointly owned by S.B.A. and the Topsøe Company, of Copenhagen, Denmark. The process enables synthesis gas for ammonia and methanol to be produced by cracking hydrocarbons.

Bulgaria

Production of ammonium chloride has now been started in Bulgaria. Hitherto this nitrogen compound has been imported but output is reported to be sufficient to meet domestic demands with some available for export. Production is based on local raw materials.

U.S.S.R.

Techmasimport of Moscow has ordered a plant from Ente Nazionale Idrocarburi, of Italy, for the production of ammonia and methanol. This plant will be in addition to that already ordered from Soc. Montecatini.

Techmashimport has concluded a contract with Société Etudes et Recherches Industrielle (E.R.I.) of Brussels for an ammonia synthesis plant. The S.B.A. process will be used and this company will co-operate with E.R.I. in supplying and engineering the plant.

At present the per-hectare consumption of plant nutrients is 3.6kg. N, 3.8kg. P_2O_5 and 5.5kg. K_2O. By 1965, the U.S.S.R. plans to have a fertilizer consumption of 52.5kg. per hectare.

MIDDLE AND FAR EAST

Syria

Construction has been started of the nitrogenous fertilizer plant at Homs. The plant will use heavy oil from the nearby refinery and will produce by 1964 55,000 tonnes of fertilizers a year, full capacity of 110,000 tonnes to be reached by 1968.

In 1960 imports of nitrogenous fertilizer by Syria amounted to 31,404 tonnes; a 10-fold increase has been recommended, however, in a United Nations report.

South Africa

Further imports of ammonium nitrate as fertilizer for the South African citrus industry have been stopped. Hitherto, the South African Co-operative Citrus Exchange, a central co-operative representing some 3,000 growers of citrus crops, has purchased from abroad large tonnages of this fertilizer material for distribution to members at cost, but the South African Treasury is unwilling to make the necessary currency available. Local fertilizer manufacturers are now supplying the Citrus Exchange with fertilizer materials at retail prices.

* See Page 13

Indian Nitrogen Fertilizer Requirements

	Ammonium sulphate	Calcium ammonium nitrate	urea	Total Tonnes N
	Tonnes Product			
Requirements of Indian States	1,769,845	313,143	252,564	551,783
Likely Supply by Government 60% of indent	1,168,098	207,334	166,692	364,482
Domestic Production	529,511	291,000	16,800	177,580
Imports	383,953	69,780	103,000	142,315
Balance to be supplied	254,645	153,446	46,892	44,587

Independent observers estimate that the balance to be supplied is: 302,920 tonnes of ammonium sulphate, 12,446 tonnes of calcium ammonium nitrate, 53,692 tonnes of urea—a total of 85,760 tonnes N.

India

Under a trade agreement with North Korea, India is to purchase 25,000 tonnes of fertilizer from that country. For the fertilizer year 1961-62, India requires, according to the Indian Ministry of Food and Agriculture, the following nitrogen fertilizers (see above).

Caltex has informed the Indian Government that the company will be unable to supply naphtha for the production of fertilizers at the proposed Vizagnapatam plant* in view of the Indian Oil Industry's decision to peg imports of crude to the 1960 level.

Negotiations are in progress between Durgapur Fertilizer Manufacturing Limited and Mitsui Bussai, of Japan, for a urea plant—capacity 160,000 tonnes a year—in Durgapur, West Bengal. U.S. competitors include Westinghouse, but if the Japanese company succeeds in its bid, Yen 1,500 million will be invested by Japan and Yen 2,300 million by India. The plant would employ the Grand Paroisse ammonia synthesis process, utilising one million cubic metres of coke-oven gas from the Durgapur Steel Works.

Fertilizers and Chemicals (Travancore) Limited, of Alwaye, Kerala State, South India, has issued tenders for delivery of complete equipment for an ammonium phosphate plant and a phosphoric acid plant.

An agreement has now been concluded by the Fertilizer Corporation of India with Burma-Shell Refineries for the annual supply of 50,000 tonnes of refinery gas for ammonia synthesis for a minimum period of 10 years. This new project at Trombay will be the first in India to use refinery gas for fertilizer manufacture. The plant is expected to start production early in 1964 at the annual rate of about 350,000 tonnes.

Burma

Tenders for the supply of fertilizers from Japan have been invited by the Burmese Government under the Reparations Agreement for 1961. A contract with Mitsubishi Shoji for 554 tonnes of compound fertilizer has now been concluded and covers 400 tonnes compound fertilizer (N 8.8%, P 16.2%, K 3.0%, Mg 2.1%) at 19,152 yen ($53.20) per tonne and 150 tonnes of compound fertilizer (N 10.5%, P 18%) at 20, 160 yen ($56.00) per tonne.

Japan

Production of fertilizer nitrogen—including calcium cyanamide—in May totalled 96,700 tonnes N. Reduced domestic deliveries and exports, mainly of urea, caused N fertilizer stocks to increase by 21,000 tonnes N. Recent export sales of urea include 5,400 tonnes to Australia, 8,705 tonnes to the Philippines, 9,072 tonnes to U.S.A., 2,000 tonnes to Hawaii, and quantities under 500 tonnes to Mexico, Brazil, Peru, Guatemala, Malaya, Singapore and New Guinea.

Nitrogen fertilizers—ammonium sulphate, urea, ammonium chloride, ammonium nitrate and high compound fertilizers—are included by MITI in the 120 items to remain non-liberalised after 1962. They will, however, be transferred to the automatic allocation schedule in the near future.

Ube Industries will use the Montecatini process in its new 120-tons-a-day urea plant. Ube already has an existing Fauser type unit with a capacity of 48,000 tons a year.

Offers of 15,000 tonnes ammonium sulphate made in July in response to a tender invitation by the Pakistan Government have

* NITROGEN No. 11, May 1961, Page 27

been refused, according to the Japan Ammonium Sulphate Export Company. The tender for which payment is foreseen from I.C.A. funds has attracted attention as a test case for I.C.A.'s "Buy American" policy. Japan now intends to offer in response to the Korean Government tender for nitrogen fertilizers, valued at $17 million, which was expected to be announced in mid-August; a refusal is however, anticipated.

Revised results for the fertilizer year ending 31 July 1961 and plans for the year 1961-62 proposed by the Ministry of Industry & Trade have been approved by the Fertilizer Council as follows :—

	1960/61	1961/62
	'000 tonnes N	
Production	986	1,040
Consumption	647	678
Exports	318	343
Stocks at end of fertilizer year ...	106	125
Stocks changes during fertilizer year ...	+21	+19

China

Synthetic fertilizer production in Communist China in 1960 amounted to 1,980,000 tonnes, compared with only 1,330,000 tonnes in 1959. Under a trade agreement signed between Poland and China, Poland is to supply a complete synthetic fertilizer plant.

South Vietnam

With the aid of part of a NF 70 million loan from France a synthetic fertilizer plant is to be built in the Tourane-Nong Son area. The South Vietnamese Government has asked for a $2 million loan for the purchase of materials from West Germany, part of which is required for the fertilizer project.

SOUTH AMERICA

Argentina

A $12 million urea plant is to be supplied by the Italian State-owned concern Finmeccanica S.A. of Rome. Soc. Montecatini is expected to design the plant and provide the necessary technical assistance for operation of the unit.

El Salvador

Continental Oil Company and National Bulk Carriers Inc. have jointly proposed for government approval a $6 million ammonia plant at Acajutla. In 1960, Fertica de Panama, an affiliate of Standard Oil Company of New Jersey, U.S.A., proposed a similar installation, but negotiations were broken off.

EXPORT PRICES

World prices hardened slightly in recent weeks, removing the weak tone prevailing in world markets during the summer months after the end of the spring fertilizer season which this year, as will be realised, had lasted longer than usual. Improving domestic demand in virtually all major producer countries, coupled with the apparent high level of overseas import requirements, notably in the Far East, is counteracting much of the uncertainty in respect of the effects of the "Buy American" policy of I.C.A. on the sales pattern of Japanese and European producers and on prices.

Ammonium Sulphate

World market prices range from $26 to $33 per tonne in bulk f.o.b. Western Europe. U.S. material, if available, is offered at prices corresponding to those on the home market. Japanese supplies continue being offered at $39.50 to $41.80 in bulk f.o.b. The bulk of exports from Western Europe are based on $28 per tonne in bulk, and range from $31 to $37 per tonne f.o.b. in bags.

Offers of ammonium sulphate, in response to a tender for 34,000 tons held by the Pakistan Government in August, ranged from $41.25 per ton c. & f. for Italian material to $47 per tonne c. & f. for Japanese material. Other Italian and Dutch supplies were quoted at $41.80 and French and other West European material at $43.50. Offers totalling 22,000 tons of Italian and Dutch material were accepted and 12,000 tons remain to be purchased.

Ammonium Nitrate

Current quotations for ammonium nitrate range from $57 to $63 per tonne f.o.b. Western

Europe and up to $86 per tonne f.o.b. Japan. Competitive offers of material from Communist countries, notably Bulgaria and Poland, continue to be in evidence.

Lime Ammonium Nitrate

Export prices quoted by West European suppliers range from $25 to $33 per tonne f.o.b. in bulk. The bulk of export quotations remains up to $1.50 per tonne below those for ammonium sulphate.

Urea

Western European suppliers quote mostly at $75 to $78 per tonne in bags, although there are still some quotes as low as $70 to $72. Exports from Japan are predominantly in the range of $87 to $95 per tonne in bags but also range as low as $74. Export sales of urea of U.S. origin are being made at $100 to $110 per tonne f.o.b. in bags corresponding to domestic price levels.

Offers under the tender for 5,000 tonnes held by the Pakistan Government in August ranger from $84 per tonne c. & f. for Dutch material to $97 per tonne c. & f. West German material was quoted at $89.04 less ½%, from Italy at $87.40 and other material from Western Europe at $88 and $97. Eventually the offer of material from Western Europe at $85.50 was accepted.

DOMESTIC PRICES

U.S.A.

Efforts made by producers to end early delivery rebates on nitrogenous fertilizers do not appear to have succeeded. For September the price of anhydrous ammonia is $84 per short ton the same as in August, as against $92 per short ton in July.

Urea price listings remain confused. During the period of weak demand of the late summer this has not been significant, but as demand starts rising in mid-September towards the autumn peak it is generally believed that a price revision is inevitable. Alternatives put forward include prices for fertilizer grade f.o.b. plant at $92.50, or delivered at $96 or $98 or a commonly adopted early delivery rebate system coupled with zoning similar to the system in force for ammonium nitrate.

U.S. Prices

Ammonium sulphate	
Coke oven	$32 per short ton, in bulk, f.o.b. works
Synthetic	$35 per short ton, in bulk, f.o.b. works
Ammonium nitrate	
Fertilizer grade (33.5% N)	$64-$67 per short ton, in bulk, f.o.b. works
Fertilizer grade (20.5% N)	$48 per short ton, in bags, *ex*-works
Nitrogen solutions	
Ammonia/ammonium nitrate	$150 per short ton (100% N) tank cars *ex*-works.
Ammonia/ammonium nitrate/urea	$158 per short ton (100% N) tank cars *ex*-works.
Anhydrous ammonia	
Fertilizer grade	$92 per short ton, tank cars, *ex*-works
Refrigeration grade	$94.50 per short ton, tank cars, *ex*-works

United Kingdom

(d/d farmer's nearest railway station per ton)

	£ s. d.	Subsidy £ s. d.
Nitrate of soda (16% N) d/d	21 18 0	6 13 4
Sulphate of ammonia (21%) d/d	19 13 0	8 15 0
Nitrochalk (15.5% N) d/d	17 9 0	6 9 2
(21% N) d/d	22 10 0	8 15 0
Nitra-Shell (23% N) d/d	24 13 0	9 11 8

West Germany

As from 1 July the price of calcium ammonium nitrate has been reduced by 5.3% or 6 pfennig per kilogramme N. Loss to producers of calcium ammonium nitrate will amount to DM 16 million, but it is hoped to increase sales of the product.

(DM per tonne N in bulk)

	September	October	November
Ammonium sulphate nitrate (26% N)	1,090	1,090	1,100
Ammonium sulphate (21% N)	1,080	1,080	1,090
Calcium ammonium nitrate (20.5% N)	1,050	1,050	1,060
Urea (46% N)	1,030	1,030	1,040
Calcium nitrate (15.5% N)	1,270	1,270	1,280

Belgium

The recently authorised nitrogen fertilizer prices for the season 1961-62 show a slight reduction for lime ammonium nitrates and ammonium sulphate of up to B. Frs. 3 per 100 kg. The impending change to higher analysis lime ammonium nitrate is not expected to be accompanied by higher product prices with the result that unit N costs to farmers will decline.

B. Frs. per 100 kg. in bulk

	September	October	November	December
Ammonium nitrate				
(20.5% N)	233	235	237	241
Ammonium sulphate				
(20.5% N)	215	217	219	222
(20% N)	207	209	211	214
Perlamide				
(18% N)	327	331	336	341
Cyanamide				
(18% N)	306	310	315	320
(22% N)	362	362	370	370

France

(new francs per 100 kg. in 20 tonne lots)

	September		October		November	
	Without taxes	With taxes	Without taxes	With taxes	Without taxes	With taxes
Ammonium sulphate						
20% N	22.17	24.63	22.53	25.03	23.01	25.57
20.6% N	22.88	25.42	23.23	25.82	23.72	26.36
21% N	23.35	25.94	23.71	26.34	24.19	26.88
Urea (prills)						
45% N	47.30	52.56	48.05	53.39	49.04	54.49
46% N	48.36	53.73	49.12	54.58	50.13	55.70
Lime ammonium nitrate (ammonitrate)						
20.5% N	21.55	23.94	21.89	24.32	22.34	24.82
27.5% N	27.68	30.76	28.11	31.23	28.69	31.88
33.5% N	32.14	35.71	32.64	36.27	33.31	37.01
34% N	32.62	36.24	33.13	36.81	33.81	37.57
34.5% N	33.10	36.78	33.61	37.34	34.30	38.11
Calcium nitrate						
15% N	20.63	22.92	21.05	23.39	21.49	23.88
15.5% N	21.31	23.68	21.75	24.17	22.20	24.67
Calcium magnesium nitrate						
13% N	19.52	21.69	19.93	22.14	20.34	22.60
Ammonium nitrate						
33.5% N	31.21	34.68	31.70	35.22	32.35	35.94
34.5% N	32.14	35.71	32.64	36.27	33.31	37.01
34.9% N	32.51	36.12	33.02	36.69	33.69	37.43
Sodium nitrate						
16% N	25.9	28.78	26.3	29.22	26.94	29.93

Spain

Current domestic prices quoted by leading producers are as follows:—

Ammonium sulphate (21% N) ... ... Pesetas 3,050-3,200 per tonne ex-works in bags ($49.50-$50.60)

Lime ammonium nitrate (20.5% N) ... Pesetas 3,395-3,375 per tonne ex-works in bags

Calcium cyanamide ... ... Pesetas 3,825 per tonne ex-works in bags

Farmers' prices are augmented by transport charges and retailers' margins.

Further Rise in Freights Expected

FOLLOWING the great activity during June, charterings for nitrogenous fertilizers have declined sharply. Freights generally have receded from the peak levels established in early summer when a number of charterers to Eastern destinations were forced to pay high rates through holding off too long.

Recent bookings for ammonium sulphate from North-West Europe to Indonesia at 75s. 0d. a ton f.i.o. are as much as 25s. a ton down. Fixtures from Rostock to India at 63s. for discharge on the West Coast and 67s. 6d. on the East Coast show a much smaller decline. From the Near Continent to South China, after dropping to 70s. the rate for sulphate has regained the June level of 75s. a ton. Urea from Heroya to West Coast India paid 75s. f.i.o. for a 5,000 tons part-cargo. A less usual chartering reported, also to Mainland China, involved an 8,400-tonner from Bourgas carrying a full cargo of calcium ammonium nitrate at 78s. 6d. f.i.o.

Outside of the Far East market there has been virtually no chartering except for two interesting fixtures to Australia. From Japan a 12,000-tonner was engaged to load urea at 41s. 0d. a ton, while from Priolo a 9,700-tonner was chartered at 80s. 0d. a ton f.i.o. to carry ammonium sulphate to Townsville and Mackay.

Autumn Freight Increases Likely

The general trend points to a sharp increase by the autumn in freights for dry-cargo ships, especially for voyages off the main sea routes or to places from which further employment cannot be obtained, such as Japan. Potash from Germany to Japan has already had to concede $12.25 a ton, an increase of nearly $2.50 in one month, and freights for "cross-voyages" such as from Australia to the Indian Ocean are the equivalent of about $3 a ton higher.

There is a feeling that during the summer season many charterers have held programmes in abeyance or have been deliberately "soft-pedalling" their tonnage needs. Before long there may well be a big increase in demand and it should be remembered that this summer has passed without the "traditional" recession despite the reduced volume of traffic compared with the early part of the year.

Grain charterers have been particularly quiet, although signs exist that they are already preparing to cover apparent deficiencies in European harvests. Their big programme, if it proves necessary this year, is likely to be deferred until October, after the crops are in and their quality and quantity can be accurately assessed. By that time the seasonal advance in oil freights (expected to occur somewhat earlier than usual this year) may have set in and tankers may require considerable financial inducements to switch into the grain trade.

Chinese Requirements

An unknown factor is the Chinese shipping requirements. Despite known requirements for grain, sugar, phosphates and fertilizers, there have been no calls for tonnage in recent weeks, although without doubt a large part of their purchases is being lifted in the big block of tonnage which they took up on time charter early this year, many of these charters, done in January and February, will shortly expire and the possibility of their engaging in new time charters cannot be excluded. On present prospects it would seem that the longer this is delayed the more costly it is likely to be.

Apart from sentiment that pressure is mounting, there is some evidence that another big rise in freights may be coming. Many shipowners are now fixing ships "forward" and if the market can be kept permanently short of prompt loaders any tendency to advance will

be magnified and accelerated. And there is at this time no "cushion" of idle tonnage to check the movement. Latest figures published by the Chamber of Shipping indicate that of the laid-up shipping there are little more than one dozen dry-cargo vessels built later than 1946, while the 50 ships built prior to World War II are unlikely to sail again and the 60 "Liberties," etc., built during that war cannot be made operational except at considerable cost.

Fertilizer Freight Statistics

The following statistics of fertilizer freights are based mainly on known charterings; but when no recent information is available "notional" rates are quoted, based on bookings for other commodities on similar routes.

N.B.: All figures are per long ton, net f.i.o., i.e., exclusive of costs of loading or discharging cargo.

Fertilizer Freights*

Importing Area	Shipment from	MONTH OF AUGUST 1961	1960	1959
South China	N.W. Europe	75s. 0d.	60s. 0d.	55s. 0d.
,,	Adriatic	60s. 0d.	56s. 0d.	53s. 3d.
India/Pakistan	Adriatic	56s. 0d.	40s. 0d.	41s. 3d.
,,	N.W. Europe	62s. 6d.	42s. 6d.	43s. 6d.
,,	U.S. Gulf	$10.60	$10.75	$9.85
,,	British Columbia	$10.00	$7.00	$7.80
India	Chile	95s. 0d.	85s. 0d.	95s. 0d.
Taiwan	U.S. Gulf	$11.50	$10.25	$9.50
,,	N. Pacific	$8.75	$6.50	$5.80
Philippines	N. Atlantic	$11.00	$10.00	$6.50
,,	N.W. Europe	$10.75	$8.00	$8.00
Greece	N.W. Europe	32s. 6d.	33s. 0d.	34s. 0d.
,,	U.S. Gulf	$8.10	$7.00	$6.35
Egypt	N.W. Europe	36s. 0d.	36s. 6d.	37s. 0d.
,,	Adriatic	22s. 6d.	23s. 0d.	19s. 6d.
Brazil	U.S. Gulf	$7.50	$6.22	$4.75
South Africa	N.W. Europe	38s. 6d.	36s. 3d.	35s. 9d.
Peru	Japan	$6.90	$6.00	$5.75

* Per long ton net, exclusive of loading and discharging costs.

More Facilities for Manufacture of Isocyanates

Continued from following page

Nippon Soda Company, which has developed its own process for toluene diisocyanates, is to offer its technique through Scientific Design Company. The Japanese company has a 10 tonnes a month pilot plant at its Takoka plant, but it is now planning to construct a 150 tonne a month commercial unit at the same site.

Mobay's New Isocyanates Plant

At New Martinsville, W.Va., U.S.A., Mobay Chemical Corporation is building a "multipurpose" isocyanates plant next to its present toluene diisocyanate unit* which is now being expanded from 40 million lb. to 50 million lb. a year. To be completed early in 1962, the plant will produce a variety of isocyanates used as intermediates for drugs, pesticides and other chemical products. Capacity of the new facility will be "several hundred s. tons a month." The range of isocyanates will include *m*-chlorophenyl isocyanates, *p,p'*-diphenylmethane diisocyanate, *p*-chlorophenyl isocyanate, octadecyl isocyanate and phenyl isocyanate.

* NITROGEN No. 12, July 1960, Page 11.

More Facilities for Manufacture of Isocyanates

New plant adds to French production

Unloading of one of two tanks, each weighing 8½ tons when full and containing 1,250 imperial gallons, forming the first bulk shipment of Du Pont Hylene isocyanate to the U.K. from Chamber Works, New Jersey, U.S.A. The tanks are 7ft. high by 6ft. 9in. in diameter and are insulated and equipped with steam-heated coils to maintain the temperature in cold weather

FORMATION of a joint company to manufacture and sell isocyanates was announced last month by Etablissements Kuhlmann of Paris and E.I. Du Pont de Nemours and Company of Wilmington, Delaware.

The new company, to be called Dekachimie, will have a capital of NF30 million. It will build a plant near Lille, at Ets. Kuhlmann's existing La Madeleine facility. Construction of the plant will begin early in 1962 and is expected to be completed in 1963. In the meantime, isocyanates from Du Pont's Chamber Works at Deepwater Point, New Jersey, will continue to be sold in the European market by the new company.

French Facilities

No details of plant capacity have been released, but it is unlikely that this plant will have an annual capacity of less than 10,000 tonnes. The plant when completed will employ 100 initially. France will therefore have three plants producing isocyanates by 1963. Now in operation is that of Société Progil-Bayer-Ugine. The second plant will be that of Tolochimie (Société Toulousaine de Produits Augignes), with a capacity of 5,000 tonnes a year. It will come into operation in 1962. According to the Fourth Five-Year Plan, production of isocyanates in France will be as follows :—

1961	...	...	...	1,030 tonnes
1963	...	...	...	6,500 tonnes
1965	...	...	...	12,000 tonnes

Bayer's Production

In West Germany Farbenfabriken Bayer AG. of Leverkusen, is the sole producer of isocyanates. Bayer's first commercial plant had a capacity of approximately 300 tonnes a month, but the plant has since been extended so that present annual capacity exceeds 10,000 tonnes.

At Leverkusen Bayer produces toluene diisocyanate, which is used in the manufacture of foams, adhesives and surface coatings and is now producing for the manufacture of elastic rubber-like products, naphthylene—1,5-diisocyanate. This material is produced by phosgenation of the appropriate amines, which themselves are produced by reduction of the dinitro compounds.

More Japanese Production

Toluene diisocyanate is to be produced by Takeda Chemical Industry at a recently acquired site in the Tokuyama area. Following the approval from MITI construction of the TDI plant has begun and it is expected that it will be completed by April 1962.

Continued on previous page

Recommendations For A Fertilizer Industry In Ecuador

Agronomic advantages in use of ammonium sulphate

AMMONIUM SULPHATE manufacture in conjunction with a sulphuric acid plant has been recommended as the first step in providing a domestic fertilizer industry for Ecuador. At the same time the scheme would produce a basic acid which could be used for the development of a chemical industry.

This suggestion was put forward in a report* written by a team consisting of George B. Beitzel, past-president, Penn Salt Chemical Corporation; Wesley R. Koster, U.S. Department of Commerce, Raymond R. Hull, The Baugh and Sons Company; and Robert P. Ogden, General Manager, Industrial Quimica Penn Salt S.A., Mexico. The team was invited by the Ecuadorean Government to study the feasibility of promoting several industries in Ecuador.

As a result of this fertilizer study it is suggested that an anhydrous ammonia operation is not feasible in Ecuador at the present time. The present supply of natural gas is insufficient and the estimated market in three to five years is not large enough to justify an economically-sized plant.

Urea as Fertilizer

The major use of urea is in agriculture and its use in industrial products is small. Urea could be produced from imported anhydrous ammonia and domestically-produced carbon dioxide, but the initial investment cost would be high and the return would be unattractive to potential investors.

Advantages for the ammonium sulphate/sulphuric acid scheme, according to the report, are :—

1. A considerable saving in foreign exchange.
2. Investment would be lower than that required for anhydrous ammonia and urea production.
3. Progressive expansion as the demand for fertilizers increases is possible.
4. Sulphuric acid could be provided for other industrial developments in the chemical industry, such as aluminium sulphate for use in water-treatment, paper manufacture, etc., and in petroleum refining.
5. Fertilizer nitrogen with suitable agronomic properties could be provided at a reasonable cost to the consumer.
6. Sulphuric acid would be available for superphosphate manufacture when phosphate demand increased to a point where a superphosphate plant could be justified.
7. With the start of phosphate production, a nitric acid facility could be added to produce ammonium nitrate for agriculture and commercial explosives.
8. A nitric acid facility would also provide another basic acid for use in industrial chemical production.
9. A fertilizer mixing operation could be added at a later date to provide complete mixed fertilizers for the Sierra and for the coastal area if needed.

As long as only ammonium sulphate was being produced in Ecuador, at the level commensurate with N fertilizer needs, it would merely be necessary to import fertilizers containing P_2O_5 and K_2O to meet the needs of the Sierra.

Agricultural Needs

Ecuador is divided into two main agricultural areas, the coastal area which grows most of the cash crops for export, bananas, cacao and coffee, and the highland Sierra region which grows mainly food crops for indigenous consumption, notably potatoes, corn,

* Report on **Development Possibilities for Chemical Fertilizers and Basic Chemicals in Ecuador**, Ecuadorean National Planning Board, Quito, Ecuador.

barley, wheat, vegetables and other crops. Increased production will be needed from this area to meet the population increase of 3% per year. Most of the cultivatable land in this area is already farmed; production costs are relatively high due to low fertility levels, and some land is being lost by heavy erosion. Improved farm management, greater fertilizer application and control of insect and plant diseases are necessary.

Diversified Agriculture

The coastal region contains large areas of virgin land which is gradually being opened up as new roads providing access to ports are built. Agriculture is well diversified; when the cacao crop failed some years ago because of disease, it was replaced by rice and coffee. Now bananas are the major factor in the export trade.

To maintain and improve her export position and increase the output of crops for home consumption, Ecuador must reduce production costs and improve the quality of the product. Adequate use of fertilizers is one of the principal means of accomplishing this.

Fertilizer use has increased steadily during the past five years and the future increase seems assured. Nitrogen-containing materials constitute the bulk of the material used in the coastal area, while in the Sierra complete mixed fertilizers are used. Present requirements are being met almost entirely by imports. This will in time cause a drain on foreign exchange and, it is suggested in the report, as much as possible will have to be produced internally if economically possible.

Types of Fertilizer Necessary

At present nitrogen is found to give the best response with bananas. Because of its relatively low cost urea has been the preferred material, but any other form, including ammonium sulphate, could be used if the cost were lower.

On cacao very little fertilizer is used, although the trees respond well. The application of 0.5lb. nitrogen per tree per year is recommended, which with the number of trees now under cultivation would mean a potential use of 17,000 tons of nitrogen a year.

Coffee also responds well to nitrogen and again a rate of 0.5lb. nitrogen per tree per year is recommended. If world markets could absorb the output and 10% of the trees were fertilized at this rate, the crop would absorb 2,000 tons of nitrogen a year. It is not expected, however, that a level of consumption in excess of 700 tons a year will be reached in four to five years.

Very little fertilizer is used on rice at present and it is not expected that its use will be very great in the future.

The potential demand from sugar cane is also very small. On areas that are fertilized a complete mixed fertilizer such as 13-13-20 is used. The response is good and production costs are reduced.

Trend Towards Complete Mixtures

In the Sierra, with its mixed crops, the tendency is almost entirely towards complete mixtures. Barley grown for brewing is well fertilized and good yields are obtained. On most of the other crops yields are low and could be greatly improved with the adequate use of fertilizers. Present estimates suggest an annual consumption of 800 tons nitrogen, 1,500 tons P_2O_5 and 650 tons K_2O. In four to five years these figures should increase to 1,500 tons, 2,500 tons and 1,200 tons respectively.

The following table shows an estimate of the present use of fertilizers by the principal consuming crops, the expected use in three to five years and the potential use if agricultural recommendations are followed :—

	Present Estimated 1960 Use—Tons (2,000lbs.)			Expected Use in 3-5 Years—Tons (2,000lbs.)			Potential Use Recommended		
Crop	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
BANANAS	4,500	110	130	8,500	300	200	10,000	xx	xx
COCOA	200	50	70	2,000	500	400	14,000	xx	xx
COFFEE	300	Nil	Nil	700	100	100	2,200	xx	xx
SIERRA CROPS ...	800	1,500	650	1,500	2,500	1,200	2,000	4,000	2,000
MISC.	200	40	50	300	100	100	500	xx	xx
TOTAL	**6,000**	**1,700**	**900**	**13,000**	**3,500**	**2,000**	**28,700**	**xx**	**xx**

From this table it appears that the requirements in three to five years will be 13,000 tons nitrogen, 3,500 tons P_2O_5 and 2,000 tons K_2O a year. The type of fertilizers required are straight nitrogen materials such as urea, ammonium nitrate, ammonium sulphate, etc., and mixed fertilizers such as 13-13-20, 12-12-17, 14-14-14 and 13-39-0.

Ammonia Production

An examination of the natural gas position showed that it was not practicable to consider the production of ammonia from this source which is located in the Santa Elena peninsula. Similarly, the use of partial oxidation of crude oil as a source of hydrogen was ruled out because of the price of imported crude oil and the size of the investment required.

If ammonia were produced domestically it would be relatively easy to add urea production facilities. The alternative of making urea from imported ammonia was considered but was again ruled out because of the high overall investment required.

Ammonium Sulphate-Sulphuric Acid

There are no agronomic objections to the use of ammonium sulphate to replace other nitrogen carriers. The advantages of the scheme have been detailed previously in this article (1 to 9). It is necessary to import anhydrous ammonia and sulphur in some form, and consequently the most logical site for the new plant would be at the port area of Guayaquil, where the imported raw material could be unloaded directly into the plant. At the same time internal transport of ammonium sulphate could be accomplished by back haul on trucks and barges delivering export products to the port area.

Sulphur Deposits Available

At present there appear to be no adequate supplies of elemental sulphur or of high-grade sulphur ores in Ecuador. There is a deposit near Tixan in Chimborazo province of caliche, containing 20 to 50% sulphur, as well as a number of small deposits of pure volcanic sulphur.

Imported elemental sulphur from Mexico was considered to be the most suitable for the initial production of acid. Use of the domestic sulphur is not, however, ruled out at a later date to save foreign exchange.

It is suggested that a vanadium catalyst contact plant producing 150 tons acid a day should be installed as the first unit for a domestic fertilizer plant. The plant should have an overcapacity of 10 to 15% and should have a waste heat boiler for the production of high pressure steam. It should be built to operate on 99.5% pure sulphur.

When the report was compiled Mexican dark sulphur cost $20.50 a long ton f.o.b. Port Coatzacoalcos, Mexico. Transport would cost approximately $5 to $6 a ton to Guayaquil, although this might be reduced if banana boats could carry the sulphur in on a back haul.

Using these figures, a production cost estimate is as follows :—

Cost of Production of Sulphuric Acid

Plant capacity 150 tons net per day basis 100% H_2SO_4	
Plant investment $850,000	Cost per net ton
Cost of land $25,000	$
Sulphur cost	8.15
Operating cost*	1.50
Supervision	.10
General administration	1.00
Depreciation (10-year basis)	1.70
Total	12.45

* Operating cost includes operating and repair labour, repair materials, power, general services.

Cost of imported anhydrous ammonia has been taken as $75 per net ton c.i.f. Guayaquil. It is estimated that an additional cost of $3 a ton would be incurred to cover unloading, handling, costs and losses. Based on anhydrous ammonia at $78 a ton and sulphuric acid at $12.45 a ton a cost estimate has been prepared for ammonium sulphate at a site adjacent to the sulphuric acid plant (see following page).

The average profit before taxes for a 10-year period is estimated at $516,000 a year, and the average percentage return on total investment as 22.2%.

Phosphate Production

As far as can be determined at present there are no phosphate deposits in Ecuador. The present use of phosphate (1,700 tons P_2O_5

a year) is not sufficient to justify a single (20%) or triple superphosphate plant. In three to five years' time the consumption is expected to reach 3,500 tons P_2O_5 a year, which may be enough to justify a single superphosphate plant provided that transport costs to the Sierra, where most of the phosphate will be used, are reasonable.

Ships delivering bananas to Tampa, Florida, could probably be used to bring phosphate rock to Guayaquil at a reasonable freight cost. With sulphuric acid available at a low cost an economical superphosphate operation could be installed once the market had developed sufficiently. It is suggested, however, that this should be deferred for the present and the situation reviewed in about two years.

Cost Estimates for Ammonium Sulphate Plant*

Plant capacity 183 tons per day—64,000 tons per year
64,000 tons at 20.6% N=13,000 tons of N per year
Plant investment $350,000
Cost of land $20,000

	Cost per net ton $
Ammonia cost	21.06
Sulphuric acid cost	9.73
Operating costs (Inc. Supv.)	1.00
Bags	3.00
Bagging and shipping	1.00
Depreciation (10 years)	0.55
F.O.B. plant cost	36.34
Sales cost	1.00
General Adm. cost	1.00
Total cost	38.34
	=$1.86 per unit N

Working capital requirements :

Annual sulphur consumption 18,000 net tons
Annual ammonia consumption 17,300 net tons

	$
Annual sulphur cost	430,000
Annual ammonia cost	1,350,000
One month sulphur supply	36,000
One month ammonia supply	112,000
One month ammonium sulphate supply	195,000
Sulphuric acid	26,000
Bags	20,000
Spare parts	41,000
	430,000
Accounts receivable, basis 60 days	
Annual sales $3,000,000	500,000
	930,000

Fixed capital requirements :

Sulphuric acid plant	850,000
Ammonium sulphate plant	350,000
Dock facilities	75,000
Ammonia storage	75,000
Land	45,000
	1,395,000

Total capital requirements :

Fixed capital	1,395,000
Working capital	930,000
Total	2,325,000

Profit and loss estimates :

Estimated Sales—1st year of operation
Ammonium sulphate—32,000 tons=6,600 tons N
Price F.O.B. Guayaquil—$47.50 per 2,000 lbs.

Gross sales—32,000 at $47.50	1,520,000	
Less cost of sales—32,000 at $38.50	1,232,000	
Profit before taxes	288,000	
Return on total investment		288,000
		2,325,000
		=12.4%

Estimated Sales—2nd year of operation
Total tons—42,000=8,600 tons of N.

Gross sales 42,000 at $47.50	1,995,000	
Less cost of sales 42,000 at $38.50	1,617,000	
Profit before taxes	378,000	
Return on total investment		378,000
		2,325,000
		=16.2%

Estimated sales—3rd year of operation
Total tons 51,000=10,200 tons of N

Gross sales 51,000 at $47.50	2,422,500	
Less cost of sales 51,000 at $38.50	1,963,500	
Profit before taxes	459,000	
Return on total investment		459,000
		2,325,000
		=19.7%

Estimated sales—4th year of operation
Total tons—64,000=13,000 tons of N

Gross sales 64,000 at $47.50	3,040,000	
Less cost of sales 64,000 at $38.50	2,464,000	
Profit before taxes	576,000	
Return on total investment		576,000
		2,325,000
		=24.8%

Profit and Loss summary.—Ten years (figures of 1,000's of dollars). (1) Assuming all capital paid in :—

	1	2	3	4	5	6	7	8	9	10
Gross sales :	1,520	1,995	2,422	3,040	3,040	3,040	3,040	3,040	3,040	3,040
Cost of sales :	1,232	1,617	1,963	2,464	2,464	2,464	2,464	2,464	2,464	2,464
Profit before taxes :	288	387	459	576	576	576	576	576	576	576
% return total invest :	12.4	16.2	19.7	24.8	24.8	24.8	24.8	24.8	24.8	24.8

A surplus of 10% to 15% production capacity exist over these estimates which could be used to produce sulphuric acid for sale to industry in general. This would increase the profits shown.

Average " Profit before taxes " for 10-year period—$516,000/year
Average " % return total Invest." for 10-year period—22.2%/year.

*At location adjacent to sulphuric acid plant. Based on anhydrous NH_3 at $78/ton and H_2SO_4 at $12.45/net ton.

current events

SOUTH AFRICA

£2m. factory for Windmill Fertilizers

A £2 million fertilizer factory is to be built at Sasolburg, South Africa, on a 50-acre site by the South African subsidiary of Windmill Fertilizers Limited (ENCK — Eerst Nederlandsche Co-operative Kunstmestfabriek), of Vlaardigen, Holland. The plant will use new chemical techniques that will reduce costs. Initial costs of the scheme will be met entirely from the resources of the South African company, and will total about £1 million. The project will be expanded in stages.

Windmill Fertilizers already has four factories in Africa—two in Durban, one at Kuistriver, Capetown, and one in Salisbury, Southern Rhodesia. These units are mixing and compounding plants only, using local materials to produce granulated fertilizers.

Sasolburg has been chosen as the site of the main South African Windmill facility because of its favourable geographical situation with regard to supply of nitrogenous raw materials—in particular nitric acid from the adjacent Sasol plant—and railway facilities. Ultimate aim of Windmill Fertilizers in South Africa is a centralised compound fertilizer plant.

INDIA

FACT's Expansion

Third stage of the expansion by Fertilizers and Chemicals Travancore Limited will be completed by 1963-64, when the plant's capacity will have been increased by seven times that in 1959. The first stage of FACT's expansion programme in which ammonium phosphate (16-20 grade) manufacture was begun for the first time in India, was completed by the end of 1960.

The company is submitting bids for two new plants. One is a 300 tonne-per-day 16-20 ammonium phosphate plant and the other is for a 100 tonne-per-day 32% P_2O_5 phosphoric acid plant.

EIRE

£7m. Nitrogen Plant for Arklow

Further consideration has been given to the construction of a nitrogenous fertilizer plant to supply domestic needs in Eire and to provide some material for export*. To this end a £7 million nitrogenous fertilizer works is to be built at Arklow based on the use of fuel oil for ammonia synthesis and Avoca pyrites for sulphuric acid production. The possibility of using peat and siting the plant near the Blackwater Bog, Co. Offaly, has been abandoned.

A special committee consisting of representatives of the Departments of Finance, Agriculture, Industry and Commerce and Transport and Power together with Bord na Mona, Ceimici Teo and the E.S.B., was formed to study the various problems connected with the economics of the project. Based on this report the Government, on the recommendation of the Minister for Industry and Commerce, Mr. Lynch, has set up a State company, the Irish Synthetic Ammonia Development Company Limited, to negotiate tenders for the plant and to operate the new industry which is expected to employ 500 workers.

Since August 1958 the Blackwater Bog has been reserved as a possible source of fuel for the production of ammonia, but Bord na Mona requested that this should now be released for the production of milled peat for electricity generation, to which request the Irish Government has acceded.

The new ammonia synthesis plant is expected to be erected adjacent to the Whitegate Oil Refinery at Cork, which is operated by a consortium of oil companies comprising Esso Petroleum and Caltex.

In addition to producing ammonium sulphate and other nitrogenous fertilizers, almost 100,000 tons of which are at present used annually in Eire, the new plant will provide a basis for a number of subsidiary industries using chemical by-products of the main manufacturing process.

The new nitrogenous fertilizer facility will not affect present development plans of Shamrock Fertilizers Limited, of Woodstock Kilcoole, Co. Wicklow, to set up a fertilizer plant at Kilmokea.

* Nitrogen No. 2, May 1959, page 42.

CANADA

Urea Plant for Sherritt Gordon Mines

Constructing a 35,000 short tons a year urea plant at Fort Saskatchewan, Alberta, is Sherritt Gordon Mines Ltd. The new unit, scheduled to be in operation by the middle of 1962, will produce both prill and crystal forms.

A modified Stamicarbon urea process will be used. The company's engineering department is acting as the main contractor and C. F. Braun and Company, of Alhambra, California, U.S.A., is providing engineering design and the major procurement service.

Raw materials—ammonia and carbon dioxide—will be obtained at low cost from Sherritt Gordon's Fort Saskatchewan nickel refining/ammonia plant. Ammonia is used to leach nickel-cobalt concentrates. Capacity for ammonia was doubled in 1960 to 60,000 s. tons NH_3 a year and a relatively small expansion whereby production will be increased by about 10 to 15 s. tons NH_3 a day is now being undertaken. Carbon dioxide will also be produced at the same site.

Sherritt Gordon is planning to market urea in the mid - western and western regions of the U.S. as well as in Canada. All sales will be handled through Harrisons and Crosfield (Canada) Limited, Toronto. Sherritt Gordon already produces anhydrous ammonia and ammonium sulphate at its chemo-metallurgical works near Edmonton. It will become Canada's third producer of urea.

Canada's first urea producer was Cyanamid of Canada Limited, of Toronto, with a 60,000 tons a year unit at Hamilton, Ontario, which has been in operation since 1959. Early this year Consolidated Mining and Smelting Company of Montreal started up its 33,000-tons-a-year plant at Calgary, Alberta.

UNITED STATES

Anhydrous Ammonia Storage Terminals

Four new anhydrous ammonia storage terminals are now under construction by American Oil Company, Monsanto Chemical Company, American Cyanamid Company and W. R. Grace to meet the increasing demand for this 82% N product by the fertilizer industry and also by industrial users, notably manufacturers of explosives, plastics, fibres, paper, and in water treatment, refrigeration and metallurgy.

At present, Phillips Petroleum Company already has ammonia storage terminals at Adams terminal, Houston, and East St. Louis, Ill., which have a capacity of 30,000 s. tons anhydrous ammonia at atmospheric pressure and 28°F.*

American Oil is building a 15,000 s. tons low-pressure refrigerated terminal on the Des

Refinery facilities, research laboratories and pilot plant of Sherritt Gordon Mines Ltd. at Fort Saskatchewan

* Nitrogen No. 12, July 1961, page 45.

Plaines River, south-west of Joliet, Illinois. Ammonia will be supplied from the Whiting, Ind., plant, of Calumet Nitrogen.
Chicago Bridge and Iron Company will start building the terminal this month.

In June, Monsanto Chemical started constructing a 15,000 s. tons capacity anhydrous ammonia storage terminal on the Mississippi River near Muscatine, Iowa. Low temperature storage will be used. Completion is expected by December. The terminal is on a 500-acre site and will be served by railroad and barge from Monsanto's ammonia plants at El Dorado, Ark., and Luling, La.

Installation of this storage facility is believed to be designed to make Monsanto competitive with Ortho Division of California Spray Chemical Corp. which is putting a large ammonia facility into operation at nearby Fort Madison, Iowa.

American Cyanamid Company has announced plans for a more than two-fold increase of its anhydrous ammonia storage units at Fortier, near New Orleans, La.

Additional railroad and tank car loading facilities are included in the $3 million expansion scheme which will increase the company's anhydrous ammonia production facilities at Fortier by 40%. Completion of the expanded facilities is scheduled for late 1962.

W. R. Grace is also to build a 16,000 s. tons refrigerated facility at Merdosia Ill.

New Railroad Tanker Wagons

Fifty new-type railway tank wagons have been ordered by Phillips Petroleum from General American Transportation Company some of which are destined to haul anhydrous ammonia to and from the company's new storage terminal. The tank wagons have a capacity of 30,376 gallons, although only 66 feet long—19 feet shorter than other wagons with the same capacity. The greater capacity has been achieved by using the double diameter technique—99 inches at each end of the car and 118 inches at the midriff. The cost of the new wagons is $24,000 compared with about $14,000 for a standard 41-foot 11,000-gallon tank car.

A significant advantage of the new railway wagon is that freight rates are only 75% of standard rates which would make them possible competitors to barges and in some cases, pipelines.

Hampshire's Success with NTA

Following the introduction of a new commercial process for nitrilotriacetic acid (NTA), which, it is claimed, gives high yields of high-purity material at low cost, Hampshire Chemical Corporation reports excellent demand and interest in this chelating agent, which is used in textile processing, detergents, rubber, etc.*

The company has reduced its prices for NTA as from August and the new price is 61 cents/lb. in truck loads. Prices of trisodium NTA at 43 cents/lb. and disodium NTA at 49 cents/lb. remain unchanged.

Hampshire — in common with Dow Chemical, Geigy and American Cyanamid — uses hydrogen cyanide as raw material in its production of NTA, but considers its process produces an improved product at a lower cost. Geigy offers its NTA—Chel NTA—at 70 cents/lb. in carload or truckload, and has recently improved its production methods but the new process does not appear to allow a price reduction below the 70 cent/lb. level.

With competition increasing in the field of chelating agents, Hampshire reports that methods are known in which NTA can be used as a partial replacement for polyphosphates.

Use of chelates in heavy duty detergents is of particular interest at present since it could form a large volume outlet. The current market for chelates in soaps and detergents in the U.S. is estimated at about 15-18% of total consumption, but it is considered that the market can be significantly increased if prices for chelating agents are attractive.

Computor for Allied Chemicals NH_3 Plant

Allied Chemical Corporation is planning to install a computor at its South Point, Ohio, ammonia plant. The installation will consist of TRW computors RW-300, the same type of unit as used by Monsanto Chemical Company at its Luling, La., plant.*

At present the South Point plant produces 900 s. tons (NH_3) of ammonia daily using the company's own adaptation of the Haber-Bosch process. The RW-300 computor, capable of 300 process variables, can perform an economic

* Nitrogen No. 11, May 1961, page 36.

optimization routine on the internally stored mathematical model of the plant. Then it will reset operating points for over 60 variables, other than instrumentation. No plant modification is required for the computor installation.

It is estimated that the total investment of about $30 million will require less than 2% increased return before taxes in one year to offset the $30,000 expenditure on the computor.

If the computor control is successful at South Point, it is expected that it will be installed at Allied Chemical's other large ammonia plant at Hopewell, Va., and La Platte, Mich.

JAPAN

Ammonium Chloride for U.S. West Coast

Export of up to 100,000 tonnes a year of ammonium chloride for fertilizer use in California and Arizona rice fields is sought by Japan. Production of this nitrogen product in Japan has risen from 130,463 tonnes in 1957 to 235,002 in 1960. A by-product of ammonia soda alkali plants, ammonium chloride is made by Asahi Glass, Tokuyama Soda, Ube Soda and Toyo Soda.

Toyo Soda produces a free flowing product as the result of a unique crystallization process for which the company has patents pending. Present capacity of ammonium chloride of Ube Soda Industry Company is 15,000 tonnes a month.

At present the use of ammonium chloride as a fertilizer in the U.S.A. accounts for 8% of nitrogenous fertilizer production. This rate is to be increased by 20% by 1963. In Japan, however, consumption has increased steadily and in 1957 production was 130,000 tonnes but in 1960 had reached 235,000 tonnes. In the next three-year period, according to the Japanese Ammonium Chloride Fertilizer Association of Japan, output is to be increased more than twofold to reach 690,000 tonnes during 1963.

One difficulty associated with the usage of ammonium chloride as a fertilizer is its corrosive effect on equipment.

It seems that to succeed in this market Japanese ammonium chloride which contains 35%N will have to be sold at highly competitive prices compared with established sources of supply.

ARGENTINA

Ammonium Sulphate Plant Completed

Fabricaciones Militares recently completed construction of an ammonium sulphate plant with a daily capacity of 40 tonnes. This plant, the first synthetic ammonium sulphate plant in the Argentine, will use ammonia from Fabricaciones Militares' 20 - tonne - per - day anhydrous plant which was completed in 1959, but has not been put into normal operation since Fabricaciones Militares is understood to be experiencing technical difficulties in producing sulphuric acid, due to the quality of the H_2S feedstock. Production is at the rate of 8 tonnes a day.

Somisa Plant in Operation

The new San Nicolas steel works, Sociedad Mixta Siderurgica Argentina (Somisa) went into operation towards the end of 1960. Ammonia liquor and sulphuric acid obtained from the coke oven gases will be used to produce ammonium sulphate. The plant is not yet in full production but the company has called for tenders for the sale of part of its production of ammonium sulphate (21%N). Capacity of the plant is 21 tons of ammonium sulphate a day.

F.M.'s New Nitric Acid Unit

Fabricaciones Militares has a new nitric acid plant which started production in July 1960 — rated capacity is 15,000 tonnes a year. The company's old plant of 2,000 tonnes a year capacity has been dismantled.

PERU

West German Consortium to Build Cuzco Plant

Contract for the construction of a nitrogenous fertilizer plant at Cuzco, in Southern Peru, has been awarded to a West German consortium consisting of Friedrich Uhde, Ferrostahl and Hochtief. The Cuzco plant will have a daily capacity of some 190 tonnes of ammonium nitrate. Power will be provided by teh Machu Picchu hydroelectric power station.

Plant construction is expected to take three years, and to cost some £5,630,000 which will be repaid after 10 years' operation.

* Nitrogen No. 9, January 1961, page 11.

Since 1957, there has been a striking increase in the consumption of nitrogenous fertilizers. In particular, imports of potassium nitrate, urea, ammonium sulphate and other nitrogenous fertilizers have almost doubled (41,103 tonnes in 1957 to 80,355 tonnes in 1959).

Peru has one synthetic nitrogen plant already in operation—Fertilizantes Sinteticos S.A. (Fertisa) at Callao.* During 1960 ammonia production of this company totalled 11,399 tonnes which enabled the company to manufacture 12,570 tonnes ammonium sulphate, 14,111 tonnes ammonium nitrate fertilizer (33% N) and 2,316 tonnes industrial ammonium nitrate (35% N) as well as 88 tonnes nitric acid (98% HNO_3) for industrial purposes. In 1961 the company's expected ammonia capacity is 19,800 tonnes NH_3 and the manufacture of 21,600 tonnes ammonium sulphate and about 35,000 tonnes ammonium nitrate is foreseen.

One of the reasons for the increasing consumption of synthetic nitrogenous fertilizers has been the falling off in guano production; until recently, the country's great natural deposits of guano provided fertilizer sufficient for domestic requirements in addition to large tonnages for export. Depletion of the natural deposits became acute, however, giving rise to a serious shortage of fertilizer at a time when Peru was expanding its agriculture. Also, although guano is an excellent fertilizer, it only contains about 8 to 12% N and 13% P_2O_5, compared with synthetic fertilizer materials with their higher N content.

U.S.S.R.

Investigation Into Manufacture of Large-Crystal Ammonium Sulphate

To overcome difficulties in the production of ammonium sulphate in large crystal sizes in bubbling saturators currently used in the U.S.S.R., Ukhin investigators† have studied the influence of mixing on crystal formation of ammonium sulphate and in particular, the design fundamentals of mixing devices — mechanical mixers, gas operated mixers and pump circulation of the liquid in the bath. Although all the methods of mixing were found to give a large-size crystal ammonium sulphate with those above 0.6mm predominating, the investigators recommend mechanical stirring or the use of a conical saturator (20 cone) with mixing by pump circulation of the liquid. In the conical saturator the speed of the current is uniform over the cross section, and for any given height in the cone crystal size of the ammonium sulphate can be closely controlled.

The mixing device, it is recommended, should be designed to provide a liquid/solid exchange related to the quantity of crystallized salt of 300 to 400:1.

†*Coke and Chemistry*, U.S.S.R. 1960 No. 10, p.40.

ALGERIA

Azotal's Fertilizer Production

Following the setting up of Société Algerienne de l'Azote (Azotal) in Algeria by French nitrogenous fertilizer companies last October to produce synthetic fertilizers from Hassi R'Mel natural gas in the Sahara, it is announced that 20,000 tonnes of ammonium nitrate and 10,000 tonnes of urea will be produced annually by the company.

Algeria's present nitrogenous fertilizer demands are met wholly by imports.

1954	34,400 tonnes	
1955	36,400 tonnes	
1956	34,300 tonnes	
1957	48,900 tonnes	
1958	58,200 tonnes	
1959	53,900 tonnes	(16,000 tonnes N)

It is estimated that demand in 1963 will be some 20,000 tonnes N which is expected to increase to 30,000 tonnes N by 1970.

Production of mixed fertilizers in Algeria is currently about 90,000 tonnes a year or 70% of demand. Ammonia for fertilizer production will be produced at the Arzew petrochemical plant which will have a unit for converting the methane gas to ammonia. Design capacity of the unit will be about 240 tonnes a day of ammonia.

* Nitrogen No. 1, February 1959. No. 11, May 1961, page 43.

COMPANY REPORTS

Consumers' Co-operative Association's Year of Growth and Expansion

"Co-operatives must meet the challenge of a changing agriculture . . . Will the control of agriculture in this industrial age be in the hands of those who think in terms of industry, or will it be in the hands of those who think in terms of farming?"

Howard A. Cowden
President
Consumers' Co-operative Association

FOR the Consumers' Co-operative Association Kansas City, Mo., 1960 was another year of growth and expansion. The volume of sales of $168 million represents an increase of over $14 million in 1959.

Co-op fertilizer outsold all other brands in the States of Kansas, Nebraska, Colorado and South Dakota. A record number of local associations (891) bought fertilizer valued at $27,237,339—a 23% increase over the preceding year and the highest on record. Mixed fertilizer sales increased 15% to $4,044,768.

Ammonium Phosphate Sales

Sales of ammonium phosphate of $5,573,795 established a new record and were greater than in 1959. Such was the demand for this fertilizer that substantial amounts had to be purchased from other ammonium phosphate producers as the Farmers' Chemical Company near Joplin was unable to supply.

Liquid Fertilizer

An 85% increase over the previous year is recorded by Co-op for sales of liquid mixed fertilizer from the Humboldt, Iowa, plant. Plant improvements are expected to raise the level of output and quality.

Nitrogen Production

Although nitrogen production was increased in 1960 at Co-operative Farm Chemicals plant at Lawrence, Kansas, the plant was unable to supply all the nitrogen products required. Demand for anhydrous ammonia continues to expand and sales increased 37% in the year under review. New equipment will raise ammonia capacity at the Lawrence plant to 380 tons a day, double its installed level when the plant began operations in 1954. Additional plant will also permit an increase of urea production to 100 tons a day. Urea is used in the manufacture of 32% N urea-ammonium nitrate solutions which last year enjoyed an 89% sales boost. Ammonium nitrate production expanded in the course of last year following completion of a 130-ton-a-day nitric acid plant.

New Facilities

New storage facilities for bulk ammonium nitrate at Lawrence are to be constructed and a plant for production of anhydrous ammonia will be built at Hastings, Nebraska. This will be owned solely by CCA., and is expected to cost $8 million, the Association's largest investment in a new facility since the nitrogen unit was built at Lawrence.

Through membership in Central Farmers' Fertilizers Company, the Association is able to supply phosphate and potash.

Kuhlmann Expanded Production Facilities and Increased Export Sales in 1960

IN the annual report for 1960 of Etablissements Kuhlmann, the rise in prices of certain raw materials, salaries, railway and other freight charges is noted, and also the marked effect on the economy as a whole of the decisions taken by the E.E.C. countries to liberate imports. To meet these problems Kuhlmann has increased production by enlarging facilities, opening new works and increasing sales to export markets.

Nitrogen Production

Natural gas from the Lacq deposits has been employed in synthesis of ammonia at Paimboeuf since the 13 June 1960. By relatively modest capital investment production capacity had been doubled. Under construction at the La Madeleine works was a new ammonia synthesis unit which would use as feedstock petroleum in place of coke. At the same works a second concentrated nitric acid unit was being installed.

Fertilizers

Production of fertilizers had continued at the same level as in the preceding year. The superphosphate granulation plant had been adapted for

production of granulated compound fertilizers. Another superphosphate granulation plant was being installed at the Loos works.

Production of ammonium phosphate has been increased to supply overseas markets and a new installation went into operation in 1960 at the Rieme works, Belgium, thereby doubling production capacity for this product.

Subsidiaries Activities

Production of ammonia by Societe de Produits Chimiques Courrieres-Kuhlmann at Harnes had increased by 8.15% compared with that of 1959. A new extension to the plant went on stream at the end of the second quarter of 1960 and another extension was now under construction. In Belgium, Societe des Fours à Coke de Selzaete was modernizing its ammonia facilities.

Finance

Turnover in 1960 rose to NF 632,966,755, an increase of 8.84% compared with the preceding year, and export sales rose by 36.8%. After deductions in respect of financial charges and depreciation, the profit and loss account showed a profit of NF 17,450,538.52 as against NF 11,936,531.11 in 1959. It is proposed to distribute NF 15,275,914.39 in the form of a net dividend of NF 5.

Air Reduction Co. Indicates Many New Plants for Nitrogen Production and Growing Usage

"1960 failed to fulfill many of the highly optimistic predictions made in the early part of the year. By mid-year . . . the prevailing mood . . . was one of uncertainty regarding the short-term future . . . Nothwithstanding, 1960 was a good year for the economy as it brought new sales records to many American business firms.

John A. Hill
President
Air Reduction Company

DURING 1960 three new liquid air separation plants, each with a production capacity of 305 tons a day of liquid oxygen, nitrogen and argon, were completed by Air Reduction Company at Fairfield, Alabama, Richmond, California, and Baton Rouge, Louisiana. A fourth plant, also with 30 S tons a day capacity, was completed early in 1961 at Tampa, Florida.

Capacity of the Richmond plant is now being doubled to meet the growing nitrogen demand in the bay area.

Nitrogen for "Blanketing"

At Baton Rouge the petrochemical industry uses large quantities of nitrogen as a "blanket" to protect chemicals from combustion or atmospheric contamination during processing and storage. In addition, petroleum processors use nitrogen for purging and pressurizing the reactors used in distillation. Another use in the Baton Rouge area is for leak detection in shipboard piping systems.

The Tampa plant, Florida's first commercial liquid air separation plant, was built mainly to supply nitrogen to the citrus industry where it is used in the processing of citrus fruit juices to prevent spoilage by contact with air.

Semi-conductors Manufacture

At Acton, Massachusetts, the capacity of the liquid air separation plant is being trebled to 200 S. tons a day of liquid oxygen, nitrogen and argon. Large quantities of nitrogen will be sold to electronics companies, particularly for the manufacture of semi-conductors.

Several on-site tonnage gas plants were completed in 1960; and several more are under construction. One at Claymont, Delaware, will supply oxygen and nitrogen to the Sun-Olin Chemical Company; and one at Phœnix, Arizona, will supply nitrogen, argon and hydrogen to the Motorola Corporation.

Nitrous Oxide as Propellant

Increased sales were recorded by the Ohio Chemical and Surgical Equipment Division of Air Reduction. A recently developed non-medical use for one of its products, nitrous oxide, is as a propellant in the pressurized packaging of meat tenderizers, barbecue sauces, cake frostings and other foods.

Sales at New Peak

During 1960 sales rose to a new peak of $202,486,344, compared with the previous highest of $200,603,636 in 1959. Net earnings after taxes were $14,692,381, compared with $14,850,600 in 1959. Earnings of common stock, after preferred stock dividends, were $3.73 ($3.81) per share.

On 24 October 1960 the properties of Air Reduction's Cuban subsidiaries, Cuban Air Products Corporation and Cuban Oxygen Company, were expropriated by the Cuban Government. Consequently, sales and earnings of these two subsidiaries have been eliminated from the 1960 consolidated net sales and consolidated net earnings. The net loss resulting from the expropriation is $2,265,496. The net income of the Cuban subsidiaries in 1959 was $346,434.

Atlas Powder Co. Attributes Decline in Earning to Replacement of Dynamite by Ammonium Nitrate

AMMONIUM NITRATE, according to Atlas, has now taken about 50% of the former dynamite market in the U.S.A., and is expected to make further inroads. It is being used in virtually every market served by the explosives industry.

Two Atlas dynamite plants were shut down during the year; the Giant plant at Richmond, California, and the Senter plant, near Houghton, Mich. Dynamite and ammonium nitrate production is now centred at the plants near Joplin, Miss., and Tamaqua, Penn.

During 1960 the Lima, Ohio, plant of Solar Nitrogen Chemicals Inc., owned equally by Atlas and the Standard Oil Company (Ohio), was expanded at a cost of $2 million, and work was begun on a new $15 million plant for Solar nitrogen situated next to the Atlas explosives division. Costs connected with these two expansions accounted for Solar's greatly reduced earnings for 1960.

Merger with Stuart Company

Shareholders of the Atlas Powder Company, Wilmington, Delaware, and of the Stewart Company, Pasedena, California, manufacturers have approved the merger of the two companies. Under the agreement the new company is to be called Atlas Chemical Industries Inc.

Each issued share of Atlas Powder Company, $20 par value common stock, will be converted into four shares of Atlas Chemical Industries Inc., $1.00 par value common stock.

The reason given for the merger by the Board of Directors of Atlas is the expansion which has taken place in Atlas research and development, particularly in food additives.

Finances

Net earnings in 1960 declined by over 23%; $2,988,000 compared with $3,907,000. The dividend was, however, maintained at 60 cents a share for each quarter or $2.40 for the year, the same as in 1959.

The decline in earnings is attributed largely to the continuing replacement of dynamite by the cheaper ammonium nitrate and substantially lower earnings by Solar Nitrogen Chemicals Inc.

1st Quarter 1961 Results

The ammonia unit at Joplin was due to be completed by late spring 1962 and the urea unit by early autumn.

The three months up to 31st March 1961 show an increase in consolidated earnings of nearly 6% compared with the corresponding period in 1960—$702,000 (92 cents a share) compared with $644,000 (87 cents a share). The operating revenue of $16,829,000 was only slightly higher than the results of $16,587,000 in the first quarter of 1960 and the management attribute this improvement to the consolidation of explosives manufacture at Joplin and Tamaque, and the shutdown of the Giant and Senter plants. It is anticipated that earnings for 1961 will be higher than for 1960.

Finalens Reports Sales of Urea Were Good in 1960

PRODUCTION of ammonia by Societe Industrielle et Financiere de Lens (Finalens) increased 6% in the year ended 31 December 1960, and there was an overall increase in the output of nitrogen products.

The urea unit which came into operation in 1957 worked to capacity taking up a large part of the ammonia output, and Perlurea has been widely accepted both by the domestic and overseas markets. Production of nitraprills was reduced due to delays in supplies of nitric acid.

Nitrogen Fertilizer Prices

As in preceding years, because of price structure of nitrogen fertilizers, ammonium sulphate is being produced more with a view to utilize available ammonia supplies rather than for any financial advantage. The sulphuric acid plant, based on Lacq sulphur, was commissioned in January 1960 and has operated at rated capacity.

	1959	1960	Change
	Tonnes		%
Ammonia	74,054	78,955	+ 6.6
Nitraprills	123,729	105,185	− 15
Ammonium sulphate ...	37,103	30,091	− 18.9
Perlurea	10,676	25,454	+138.4
Sulphuric acid	36,363	44,238	+ 21.6

Sales

In the fertilizer year 1959-60, and particularly during the second half of 1960, French consumption of nitrogenous fertilizers increased, and the company's sales reflected this.

End Year Stocks

Sales	1959	1960	Change %	Stocks at end 1960
Anhydrous ammonia ...	3,753	9,000	+139	—
Nitraprills	122,041	117,758	− 3.6	454
Ammonium sulphate ...	35,041	29,981	− 16.3	4,019
Perlurea	6,892	27,364	+297	1,877
Sulphuric acid ...	17,398	20,956	+ 20	—

Stocks of Nitraprills and Perlurea were abnormally low, corresponding only to two days' production in the case of the former and less than one month's for the latter.

Sales of urea were good in 1960 as there were only two French producers. Future sales are expected to be more difficult, however, as two more producers will be in operation. World markets are available and it is hoped to make up sales in these.

Sales of technical urea and sulphuric acid have developed well and are playing an important part in the company's affairs, particularly in providing a diversification of Finalens' interests.

Results

Prices of nitrogenous fertilizers were the same in 1960 as in 1959 with the exception of ammonium sulphate, the price disparity of which was remedied. Only expansion and technical progress, however, has enabled Finalens to face the situation satisfactorily. Stability in the sale price of nitrogenous fertilizers is considered to be essential to ensure satisfactory expansion of sales.

Finances

Turnover, excluding taxes, rose to NF 68,441,000, an increase of 19%.

A second payment of NF 1 million has been made to the Credit National in respect of the loan obtained for the new urea unit. To finance a part of the cost of doubling the capacity of the urea plant NF 2.5 million was obtained from the Groupement de L'Industrie Chimique de Synthese. In accordance with the law passed on the 28 December 1959, plant and equipment, etc., has been revalued to NF 36.83 million, an increase of NF 3.32 million. A dividend of NF 3.783, corresponding to NF 2.90 net as against NF 2.80 in the previous financial year, has been proposed.

New Projects

Installation of a compressor has enabled the company to reach the daily production of some 260 tonnes of ammonia.

In the nitric acid plant a Montecatini pressure reactor is operating satisfactorily.

In an effort to diversify, Finalens has decided to double the urea plant, despite the fall in price. Initially an output of 100 tonnes a day is expected to be attained by the middle of 1961. Production of ammonia solutions is being studied by Finalens.

CORRIGENDUM

Isocyanate plant capacities

In Nitrogen No. 12 (July), page 15, isocyanate plant capacities for Allied Chemical Corporation at Moundsville were omitted in revising the table to include late information.

Isocyanate Plant Capacities

(mill. lb.)	1960	1961	1962
U.S.A.			
Mobay			
New Martinsville 25 ...	—	40–50	50
W.Va	25	—	—
E.I. Du Pont de Nemours Incorporated			
Deepwater, N.J.	25	35–40	40
Allied Chemical Corp.			
Moundsville W.Va. ...	8	25	25
South California (no site selected)	—	—	15
Nopco Incorporated			
Linden N.J.	—	—	10
Carwin Company			
North Haven, Conn. ...	0.5	0.5	0.5
Houston, Texas	0.5	0.5	0.5
Total Installed ...	**59.0**	**101–116**	**141**

(Tonnes)	1960	1961	1962
France			
Progil-Bayer-Ugine			
Pont-de-Claix ...	—	1,700 (4mts.)	5,000
Soc. Toulousienne de Produits	—	—	5,000
West Germany			
Farbenfabriken Bayer AG.			
Leverkusen	5,000*	7,500*	10,000*
Italy			
Soc. Montecatini ...	—	—	—
Japan			
Takeda Chemical Ind.	—	365	1,460

(Tons)	1960	1961	1962	1963
U.K.				
Imperial Chemicals Industries Ltd				
Wilton	2,000+	—	—	—
Fleetwood	—	5,000*	14,000*	14,000*–15,000
Du Pont (U.K.) Ltd. ...	—	—	—	10,000–*
Maydown, Nr. Londonderry, N. Ireland ...	—	—	—	15,000*

\+ Production * Estimated

Statistical Appendix

UNITED STATES OF AMERICA

Production
(Short tons)

	Anhydrous Ammonia synthetic	Ammonium Nitrate (100% NH_4NO_3) total	Ammonium Nitrate (100% NH_4NO_3) fertilizers	Ammonium Sulphate synthetic	Ammonium Sulphate by-product	Nitric Acid (100% NHO)	*Nitrogen Solutions (100% N)
1958 TOTAL	**3,878,778**	**2,581,312**	**2,358,780**	**1,090,956**	**640,416**	**2,704,062**	**624,221**
1959 TOTAL	**4,519,705**	**2,957,435**	**2,634,871**	**1,093,433**	**620,235**	**3,074,401**	**779,745**
1960 TOTAL	**4,812,120**	**3,102,661**	**2,812,693**	**871,721**	**632,431**	**3,316,082**	**819,125**
1958, 1959 are revised figures and 1960 are preliminary.							
1960							
January	396,403	278,030	244,356	97,261	68,933	287,981	63,783
February	381,279	263,572	231,884	93,595	66,563	280,709	65,907
March	423,351	288,066	263,583	76,254	69,715	304,503	76,714
April	416,220	255,396	231,135	68,683	63,929	275,457	104,960
May	434,043	243,550	219,387	65,078	61,385	265,080	102,916
June	407,907	208,670	185,816	52,195	49,645	234,603	60,629
July	382,292	218,896	200,293	58,914	45,307	242,362	44,414
August	380,339	236,459	215,881	63,906	44,197	255,250	50,697
September	364,850	259,279	233,440	70,961	40,380	281,001	53,792
October	387,282	273,096	250,684	86,236	42,572	288,004	60,280
November	408,625	279,173	259,948	74,905	37,415	300,169	63,326
December	429,529	298,474	276,286	63,733	42,390	300,986	71,702
1961							
January	411,757	282,080	106,887	59,992	41,877	285,788	66,161
February	400,611	269,351	108,529	68,305	41,065	272,534	72,585
March	463,302	287,166	125,350	78,115	46,301	295,406	91,422
April	460,224	267,656	112,974	73,853	48,423	277,017	108,412
May	477,508	254,487	105,591	68,418	52,534	274,740	90,150

* Including combinations with urea.

Exports: Fertilizer year 1959-60
(Short tons)

AMMONIUM SULPHATE

Greece	6,063
Spain	133,557
United Kingdom	16
Canada	2,755
Bahamas	70
Costa Rica	150
Cuba	37,090
Dominica	4,729
Honduras	100
Br. Honduras	100
Mexico	10,037
Argentina	3,712
Brazil	26,730
Bolivia	11
Colombia	5,552
Peru	546
Venezuela	429
Uruguay	1,873
Korea South	11,026
Total	**244,493**

UREA

Canada	2,065
Bahamas	9
Costa Rica	5,011
Cuba	761
Guatemala	468
Br. Honduras	5
Honduras	2,397
Haiti	239
Jamaica	336
Mexico	9,588
Nicaragua	35
Panama	1,103
Salvador	40
Brazil	200
Colombia	4,695
Ecuador	1,486
Paraguay	4
Venezuela	161
Indonesia	31
Korea South	5,016
Philippines	1,716
New Guinea	22
France	393
United Kingdom	11
U. of S. Africa	300
Total	**36,092**

OTHER NITROGENOUS FERTILIZERS

Canada	18,484
Bahamas	236
Bermuda	20
Costa Rica	30
Cuba	21,895
Br. Honduras	336
Honduras	15
Mexico	169
Nicaragua	25
Salvador	500
Brazil	551
Ecuador	11
Peru	6
Uruguay	2
Korea South	5,014
Australia	10
U. of S. Africa	30
Italy	30
Total	**47,364**

SODIUM NITRATE

Canada	363
Bermuda	60
Cuba	20
Mexico	283
Panama	27
Others	63
Total	**816**

AMMONIUM NITRATE

Bahamas	20
Dominica	160
Honduras	50
Jamaica	185
Mexico	18,984
Salvador	15
Brazil	175
Chile	2,365
Colombia	300
Ecuador	80
Peru	3,276
Suriname	30
Korea South	29,418
Pakistan	10
Pacific Is.	20
Philippines	280
Taiwan	175
Thailand	150
Australia	140
Arabia	600
Liberia	70
Israel	99
Greece	4,409
Iceland	3,196
Sweden	60
Total	**64,267**

ITALY

Production

(tonnes)

	Ammonium Sulphate (20.21%)	Ammonium Nitrate (20.26.5%)	Ammonium Nitrate (33.35%)	Calcium Nitrate (15.5%)	Sodium Nitrate (15.16%)	Calcium Cyanamide (15.16%)	Urea (44.45%)
1959							
July	91,579	55,076	426	22,761	1,278	22,214	5,721
August	100,648	56,846	770	16,143	452	21,286	6,144
September	95,363	52,648	970	23,424	515	17,128	5,500
October	108,940	62,088	1,152	24,645	355	13,818	6,900
November	105,230	46,707	1,581	25,018	392	2,818	6,668
December	104,557	51,314	414	32,346	604	2,586	7,060
1960							
January	100,964	68,434	1,256	28,620	369	1,884	7,070
February	95,911	68,376	865	28,578	286	578	6,367
March	107,443	49,381	1,227	34,569	648	6,411	6,685
April	98,284	53,723	953	31,186	561	10,366	6,746
May	109,240	60,131	1,390	30,126	775	18,314	6,985
June	106,028	73,780	1,191	25,571	647	16,062	6,800
July	110,865	71,498	775	30,885	865	14,503	5,990
August	109,412	72,614	1,467	31,350	854	14,310	9,419
September	101,746	68,009	590	27,250	335	14,692	10,855
October	103,000	68,009	1,239	32,547	801	12,454	10,906
November	95,172	72,760	1,277	28,833	281	8,224	10,882
December	109,519	73,052	780	35,046	588	9,216	10,920
1961							
January	106,938	59,858	899	37,786	315	4,835	11,635
February	109,054	50,928	729	28,334	663	1,813	10,823
March	114,253	62,234	1,371	26,764	492	2,098	10,917
April	116,759	75,763	1,417	24,585	710	7,769	11,868

Exports

(tonnes)

AMMONIUM SULPHATE

Country	1958/59	1959/60
Argentina	1,613	—
China	151,318	290,152
Greece	81,959	66,761
Ireland	507	—
India	19,305	64,649
Indonesia	10,317	—
Iran	1,089	—
Korea South	38,038	—
Libya	595	—
Malta	446	—
Pakistan	9,578	21,550
Spain	—	158,050
Sudan	1,485	—
Turkey	53,673	—
Uganda	457	—
Uruguay	3,642	—
Others	22,786	61,661
Total	**396,808**	**662,823**

UREA

Country	1958/59	1959/60
Brazil	506	—
China	20,796	28,261
Colombia	147	—
France	20	—
India	20,020	3,510
Philippines	454	—
Portugal	120	—
Sudan	10,639	19,594
Taiwan	65	—
Others	3,347	2,333
Total	**56,114**	**53,698**

AMMONIUM NITRATE

Country	1958/59	1959/60
Australia	402	—
Bulgaria	31,942	59,780
China	81,881	99,719
Cyprus	3,731	—
Egypt	117,596	103,234
Greece	35,117	58,169
Iran	3,596	—
Israel	2,961	—
Sudan	495	—
Turkey	—	—
United Kingdom	553	—
U.S.A.	3,175	—
Yugoslavia	81,527	41,813
Austria	—	3
Others	12,263	56,172
Total	**375,239**	**418,890**

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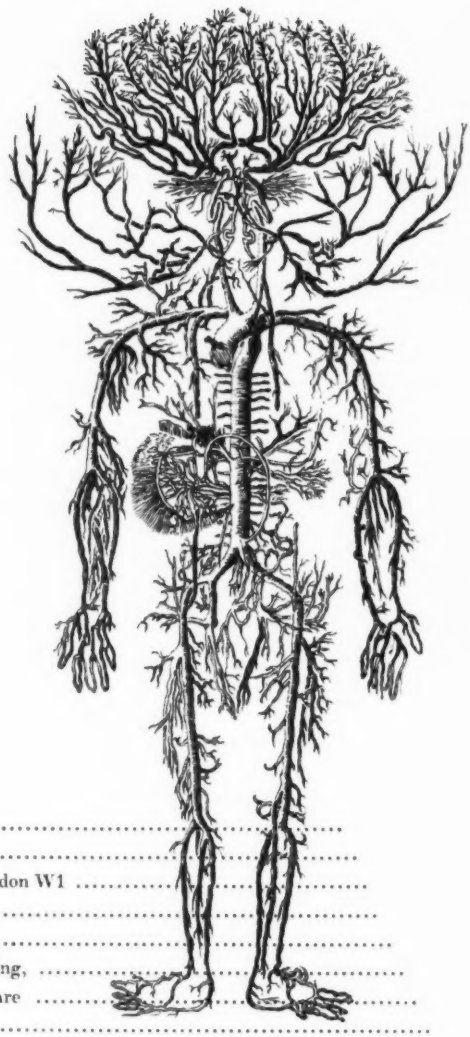

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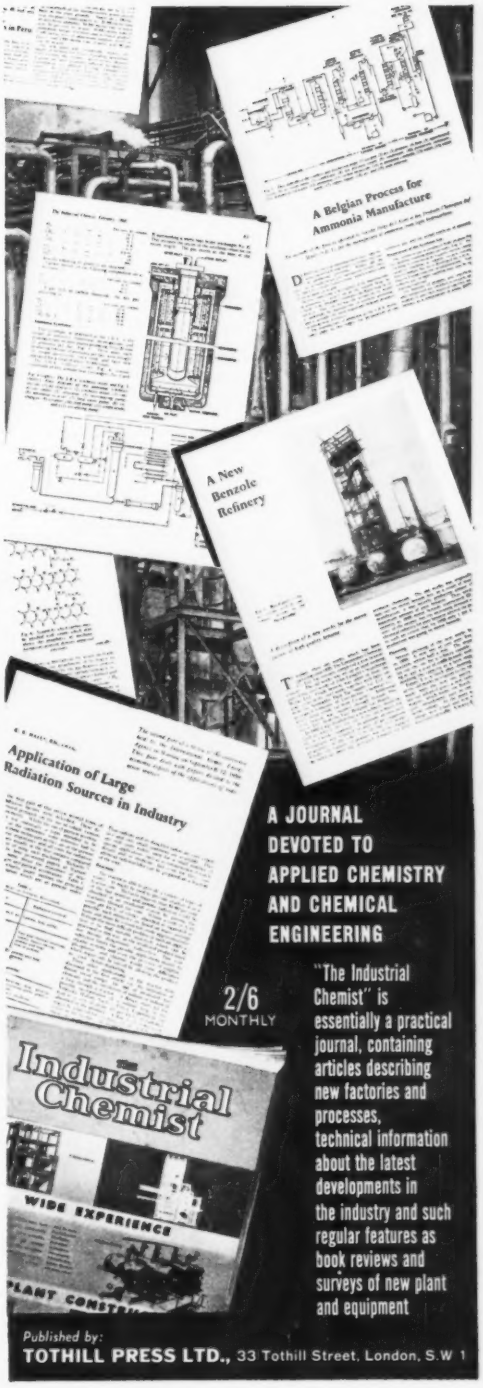
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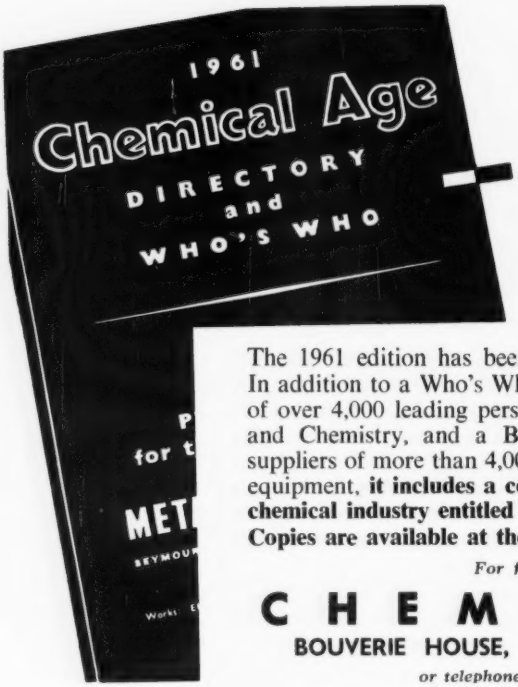

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